

the  
**gilt-edged**  
market

Moorad Choudhry  
Graham 'Harry' Cross  
James Harrison

Foreword by Mike Williams  
Chief Executive, UK Debt Management Office



# **The Gilt-Edged Market**

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*Moorad Choudhry*  
*Graham “Harry” Cross*  
*James Harrison*

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*For Anuk, a most exciting and exotic creature...*  
Moorad Choudhry

*To Julie and my wonderful sons Ciarán and Riley for their continuing  
patience and understanding of my frequent forays into the  
literary world.*  
Graham "Harry" Cross

*To Moorad for remembering my small part in his great career.  
To Harry for jobbing me out of a £17,000 misunderstanding  
one afternoon.  
And especially, to my wife Linda – thank you for the constant love  
and support you give to your ex-Trader.*  
James Harrison

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# Foreword

I was pleased when Moorad Choudhry approached me to write a Foreword to this book. It is a most welcome addition to the library or desktop. The outstanding volume of gilts may have fallen proportionately a little in recent years, not least as inflation and borrowing have been brought under control. But gilts and the gilt market still have a central and crucial role in the UK sterling markets. The gilts market has an annual turnover equivalent to more than six times its market value; the gilt repo market has grown rapidly and is now about one-quarter of the sterling money markets; the gilt yield curve remains the benchmark for pricing sterling swaps and corporate credit; and gilt collateral underpins the UK's wholesale settlement and payment systems. The market is increasingly transparent to investors and practitioners and those regularly active in the market have good access to techniques, institutional understanding and data. But that is less the case for those on the edge of the market or non-participants. Moorad and his co-authors are to be congratulated for filling this gap by bringing together a large amount of information and making it readily accessible to interested readers whether in the financial markets or not.

The book is also timely. The gilts market has changed hugely since the reforms initiated by HM Treasury and the Bank of England in 1995, and carried forward by the UK Debt Management Office (DMO) after it took over the Bank's responsibilities in 1998. These reforms have made the market more predictable and more transparent, to the benefit both of the issuer – and hence to UK taxpayers – and of investors. In the process these reforms have blown away much of the local quirks and complications of the market that were too often off-putting to many investors, particularly those from overseas. But although auction techniques and bond characteristics are now in line with best practice worldwide, there is still a need for the analytical and institutional understanding set out here.

Reform of course means change, and some feel that the gilt market has lost its charm in the process. Maybe, and perhaps that was essential to allay investor concerns about lack of transparency. But there are still plenty of good stories; and the reminiscences here by Harry Cross and James Harrison give the reader a good feel of where the market has come from, not so very long ago.

When the DMO was established in 1998, the gilt market was moving from some years of heavy government borrowing into a period of fiscal surplus. As I write, borrowing is increasing again, although consistently with a stable and historically low ratio of public sector debt to GDP. We have had three years of negative net issuance – gross borrowing falling short of redemptions. This has created its own challenges both for the DMO and the market. To facilitate gilt market liquidity the DMO has run a number of conversions and buy-back operations – to retire old liquid stocks, in favour of building up more liquid benchmark stocks – and switch-auctions – again to reduce the amount outstanding of some stocks, in favour of benchmarks. We now (October 2002) have just 59 stocks outstanding compared with 80 as at end-March 1998; and the 20 largest stocks account for 73% of the market in terms of uplifted nominal value compared with 60%.

In 2000, following the huge unanticipated inflows from the sale of third generation mobile phone licences, we still maintained some issuance, choosing to smooth issuance

over a 3–4 year period rather than temporarily cut the flow of gilts completely. That decision recognised the importance to the Government of sustaining gilt market liquidity and investor interest in the light of the forecast increase in the financing requirement over the subsequent few years. During this period too we have shown that we can respond to market and investor needs, both in the way that we have biased our issuance, toward long-dated and index-linked stocks, reflecting the strong demand from UK pension and insurance funds; and by introducing other measures to facilitate an effective market place, such as the standing repo arrangement and the recently introduced mandatory quote obligations on market makers in the inter-dealer market. The gilt market investor base is wide, although UK pension and insurance funds remain the main holders of gilts, reflecting their very strong role in the UK financial sector; the average duration of gilts outstanding is longer than that in any other major country's government bond market; and index-linked gilts comprise a higher proportion (approximately 25%) of the outstanding total than in any other large country.

The measures taken since the mid-1990s have taken the UK close to the yardstick of international debt management best practice. Certainly the gilt market remains hugely important to the DMO and to the Government more generally. Small changes in markets can potentially have a significant impact on Government finances in the short or long term. All Government debt managers have the objective to finance the Government's borrowing needs at the finest interest rates available, but also to do it in a way that is sustainable over time and does not leave the total debt interest bill vulnerable to adverse macro-economic developments. That in turn requires a flexible and liquid government bond market. The DMO will continue to play its part in this, and I welcome this book as a way of widening understanding of the issues.

**Mike Williams**

Chief Executive

United Kingdom Debt Management Office

# About the Authors

**Moorad Choudhry** was educated at Claremont Fan Court school in Surrey, and joined the London Stock Exchange from the University of Reading in 1989. He was a gilt-edged market maker at ABN Amro Hoare Govett Sterling Bonds Limited, and later a gilt proprietary trader at Hambros Bank Limited. He currently works in structured finance services with JP Morgan Chase Bank in London. He is a Fellow of the Securities Institute and a visiting Professor at London Metropolitan University.

**Graham “Harry” Cross** was a gilt-edged market maker at Greenwich NatWest, ABN Amro Hoare Govett Sterling Bonds Limited and UBS Philips and Drew. He currently works in the fixed income unit at Van Der Moolen UK.

**James Harrison** started his Stock Exchange career with Sheppards & Chase in 1972. He was made a dealer in 1974 and left in 1981 to enter the gilt market with Carr Sebag. From there he joined Grieveson Grant, trading the long end of the gilt market. Following “Big Bang” in 1986 Grieveson was bought by Kleinwort Benson, with whom Jim was a fixed interest market maker. He left Kleinworts in 1988. In 1992 he was invited back to resume sterling fixed interest trading with ABN Amro Hoare Govett Limited. He now works for the Global Securities Services division of Mellon Bank. Jim is a member of the Securities Institute.



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# Preface

This book focuses on the United Kingdom government bond market, otherwise known as the gilt-edged or gilts market. It is designed to be an overview of all aspects of the market, from issuance in the primary market to trading and analysis in the secondary market. The contents are aimed at anyone with an interest in the UK bond markets, but should be particularly useful for front office, middle office and back office staff working in banks, fund managers and other financial institutions and who are involved to some extent in the gilt market or sterling bond markets. Comments on the text are welcome and should be sent to the authors care of Butterworth-Heinemann Finance.

## Layout of the book

This book is organised into twelve chapters. These cover an introduction and history of the United Kingdom gilt market, as well as a detailed coverage and analysis of all aspects of the market. There are separate chapters on conventional gilts, index-linked gilts, gilt repo and the gilt strips market.

In Chapters 7 and 8 we consider the gilt bond basis, with a discussion of trading the basis using the LIFFE long gilt futures contract. Chapter 9 looks at the information content of the gilt yield curve, while in Chapter 11 we look in some detail at yield spreads and relative value trading using gilts. This is based partly on the authors' experience in the gilt market.

Where this book differs perhaps, from more conventional market text books, is in its inclusion of personal reminiscences of actually working in the gilt market. These are from the recent and not-so-recent past, and are intended to put some colour on the more technical treatment of market aspects.

## Website

Research on the debt capital markets may be downloaded from the dedicated fixed income website at

[www.YieldCurve.com](http://www.YieldCurve.com)

This site also lists details of other books and articles written by YieldCurve.com associates.

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# Acknowledgements

Olga, thanks so much for the great cartoons . . .

Special thanks to Sean Baguley for recruiting me into that esoteric but wonderful thing, the sterling bond market.

Thanks to Patrick Phillips for letting me have a copy of his excellent book *The Guide to the Gilt-Edged and Sterling Bond Markets* (The Book Guild 1996). I have made some use of the data in this book and freely acknowledge the source; there's certainly no point trying to improve on it because one can't! This book remains a top reference (for instance, the section on sterling bonds remains the best source on this market and I haven't attempted to add to it here), and I'd like to start a petition now to have it re-printed: I certainly heartily recommend it . . .

A big thank you to Mike Williams at the UK Debt Management Office for the excellent foreword. Thanks to Gurminder Bhachu at the DMO for correcting errors in a previous draft.

Thanks to Michael Nicoll, Jonathan Rossington and Stuart Medlen – surely the coolest dudes ever to work in the City? (Not to mention the finest footballers!) A pleasure and a privilege to know you.

It's always great working with the guys at Financial World Bookshop, on Bishopsgate, so a big thanks to the team who put on the coolest launch party in town, Sharon, Jenny, Rob and Radhika. Say hi to Gerry for me . . .

Mogser, I hope you know that playing on the same team as you in our 5-a-side footy matches always inspired me to give it 110%.

Huw, Nick, Clive and Greeny – now there's a top team. Cheers. The Big M.

I used to trade gilts, and during that time developed particular likes and dislikes for certain stocks; sadly all these have long since matured (the most recent stock that I'd ever traded will have expired by the time you read this, the 7% Treasury 2002, on 7 June 2002). However I reserve a particular fondness for the 10¼% 1995, 14% 1996 and the 10% 1996, while only now admitting to being secretly terrified of the 15% 1996 and 13¼% 1996. But I'm proud to say I was long the 6% 1999 when that bond went very special during 1997. Those were the days . . . if only I'd known then what I know now, eh? . . . Perhaps this book is something of an exorcism . . . Anyway thanks, for one last time, to John Gruby, John Kitching, Ian Coe, Richard Smith, Simon Smith, Giles Fitzpatrick, Graham Leach, Malcolm White, Jim Harrison, Kevin Gaffney, John Lenton, Peter Matthews, Tony Alderman, David Dodds, Harry Cross and of course Mr Sean Baguley. All the best chaps.

**Moorad Choudhry**  
Surrey, England  
31 May 2002

“Education never ends, Watson. It’s a series of lessons, with the greatest for the last.”

– The Adventure of the Red Circle

*His Last Bow*

Sir Arthur Conan Doyle

(1859–1930)

Meetings generally were held in low regard and not viewed as being real work. “He spends all his time in meetings”, was one of the most damning comments that could be made about an individual.

– Philip Augar, *The Death of Gentlemanly Capitalism* 2000

# 1 The Gilt-Edged Market: An Introduction

The gilt-edged market is the market in bonds issued by the government of the United Kingdom. Bonds are debt instruments that exist to fulfil the needs of borrowers and lenders of capital, and may be issued by any entity or individual of good credit standing. The term “good” is of course relative, and the credit quality of bonds issued around the world varies considerably. In this book, apart from a small bit about sterling bonds issued by non-government borrowers, we won’t have to worry about credit quality. This is because bonds issued by Her Majesty’s Government carry the highest credit rating possible; indeed, default by such an issuer is unthinkable and were it to happen, it is safe to assume that bondholders will have quite enough on their plates without having to worry about the value of their investments.

Gilts carry the highest credit rating because they are guaranteed by HM Government. They are issued to cover the shortfall that exists between the level of spending undertaken by the government and the amount of funds it raises through taxation. This shortfall is known as the National Debt and also includes National Savings. By far the largest part of the National Debt though is covered through the issuance of gilts.

## **The origins of the gilt-edged market<sup>1</sup>**

The first occasion when the UK government had to raise funds was in 1694, when King William III borrowed £1.2 million required to fund a war against France. This can be considered the first gilt issue, and very shortly afterwards the Bank of England was formed.<sup>2</sup> At the end of the war in 1697 the size of the government debt stood at £15 million. Thereafter it rose irregularly, generally in circumstances of war. In 1751 the Bank issued 3% Consolidated Annuities, and many smaller-size issues were incorporated into this bond, a practice that continues to this day. At this time gilts were held by

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<sup>1</sup> The information source used for this section is Phillips (1996), an excellent book and one that will be referred to by the author occasionally! Statistical and other facts are reproduced with permission of the author and the publishers.

<sup>2</sup> Phillips (*ibid*) tells us that this first loan was raised at 8% in perpetuity. This loan remained on the balance sheet of the Bank of England until 1994, three hundred years after it was raised! The Bank of England remained a private institution until it was nationalised in 1946.

merchant companies such as the East India Company, and it was not until 1783 that they were issued by public tender. In 1844 the distinct role of raising funds via gilt issue was recognised when a separate division of the Bank, the Issue department, was created and given this responsibility. Banking supervision was undertaken by the Banking department.

In 1853 the first redeemable bond was issued. Prior to this, all gilts had been irredeemable issues. Nowadays irredeemable gilts are not issued, and nor are they likely to be, and the only ones in existence date from some time ago. For example in 1888 a conversion of small issues into one issue became the 3% Consolidated (Consols), which featured a stepped-down coupon, falling to 2½% Consols of 1923 or after. This stock is still in existence today.<sup>3</sup>

The size of the National Debt rose considerably at the time of the 1914–18 war, and then again during and after 1939–45. At the end of the second World War the level of debt stood at £21 billion. In the post-war period debt levels rose still further as industries were nationalised. An annual government budget deficit has become (in common with other developed and developing economies) the norm in the UK, with occasional exceptions such as during 1988–89.

Up until 1986 the structure of the gilt market centred on the stock jobbers who provided two-way dealing prices to the stockbrokers. The jobbers acted as principal and ran their gilts books for their own profit. The brokers acted as agents on behalf of investors. The market operated under a “single-capacity” arrangement, which meant that a firm could act either as a jobber or a broker, but not both. Dealing took place face-to-face on the floor of the Stock Exchange in the City of London. In 1986, in parallel with the impact of “Big Bang” on the equity market, the Bank of England remodelled the gilt market, basing it on the US Treasury market. The effect of this was that firms could act in a dual-capacity role and trading left the floor and was conducted over the telephone, with prices displayed on electronic screens. Liquidity was provided by market-makers who undertook to provide continuous two-way prices to institutional clients and stockbrokers.

In 1997 the government handed responsibility for setting interest rates to the Bank of England, which set up the Monetary Policy Committee, chaired by the Bank’s governor, to undertake this role. It was felt that there may be a perceived conflict of interest between setting interest rates and issuing gilts, so the latter function was transferred to a new executive agency of the Treasury, the Debt Management Office (although it was pointed out that the US Federal Reserve manages to combine both these roles without any hint of impropriety). The DMO began operations in 1998 and is responsible for managing the government’s debt requirements and also its short-dated money market requirements.

---

<sup>3</sup> The only irredeemable stock of any size today is 3½% War Loan of 1952 or after, which was first issued as a conversion in 1932, from an earlier bond issued during the 1914–18 war. It is common to read that holders of this bond witnessed a big fall in the value of their investment, which is certainly true if one compares the bond’s value today with the par issue price in 1932 . . . however, War Loan traded as high as £109 per cent and £110 per cent in 1934 and 1935, so the original holders certainly did have an opportunity to realise their investment at a profit.

The term “gilt” comes from *gilt-edged securities*, the official term for UK government bonds.<sup>4</sup> Gilts are the main method by which the UK government finances the shortfall between its expenditure and its tax revenues, and as they are direct obligations of the government they are the highest-rated securities in the sterling market. Their AAA-rating reflects in part the fact that the UK government has never defaulted on an interest payment or principal repayment in the history of the gilt market, and in part the strength and standing of the UK economy. The market is also at the centre of the sterling financial asset markets and forms the basis for pricing of all other sterling assets and financial instruments.

In June 2002 there were 42 individual gilt issues in existence, together with a further 19 “rump” or illiquid stocks, representing nearly £252 billion nominal of debt outstanding. The majority of these are conventional fixed interest bonds, but there are also index-linked, double-dated, irredeemable and floating rate gilts. A full list of gilts in issue as at 1 June 2002 is given at Appendix 1.1.

The UK government issues gilts to finance its income deficit, previously known as the Public Sector Borrowing Requirement but now known as the Public Sector Debt Requirement. The actual financing requirement each fiscal year is known as the Central Government Net Cash Requirement (CGNCR). The CGNCR, being the difference between central exchequer income and expenditure, always reflects a borrowing requirement except on rare occasions when the central government runs a surplus, as in 1988 and in 1998. New issues of debt are also made to cover repayment of maturing gilts.

The responsibility for issuing gilts rests with the Debt Management Office (DMO), an executive agency of Her Majesty’s Treasury. The DMO is in charge of sterling debt management for the government. This transfer of duties traditionally performed by the Bank of England (BoE) was introduced after the Chancellor of the Exchequer handed over control of UK monetary policy to a committee of the Bank, the Monetary Policy Committee, in May 1997. The DMO was set up in 1998 and assumed its responsibilities on 1 April 1998. Prior to this the gilt market had been subject to a series of reforms in its structure and operation over the past few years, overseen by the BoE, designed to make gilts more competitive as investment instruments and to bring the market up-to-date. Recent innovations have included the introduction of an open market in gilt repo and a new market in zero-coupon bonds known as gilt strips, as well as improvements to the auction process. This included introduction of an auction calendar and a policy of building up large volume, liquid benchmark issues. The changes were designed to enhance the efficiency, liquidity and transparency of the market. The gilt market is an important world bond market and in this book we will look at the structure and make-up of the market today, and in greater detail at recent reforms and structural changes. We also review related products such as the exchange-traded gilt futures contract and gilt repo.

United Kingdom national debt dates from 1694 when the government of King William III raised £1.2 million in order to finance a war against France. The Bank of England was founded the following year. The currency itself, however, dates from much earlier than this,

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<sup>4</sup> The legend is that the term “gilt-edged” was used to refer to British government bonds because certificates representing individual bond holdings were originally edged with gold leaf or *gilt*. This tale is almost certainly apocryphal. Another commonly heard explanation is that UK government bonds were deemed to be as “good as” (as safe as) gold, hence the term “gilts”.



for instance the word *pondus* was a Latin word meaning “weight” but signified the weight of the coin of money; while the “£” sign originates from the designation for “Libra”, used to denote the pound. The term *sterling* originates from “esterling”, silver coins introduced during the reign of King Henry II in the twelfth century.<sup>5</sup> From this beginning the UK national debt has grown steadily, experiencing rapid growth during the wars in 1914–18 and 1939–45. The nominal value of the debt stood at £418 billion in March 1998.<sup>6</sup> Appendix 1.2 lists the growth of the UK national debt from inception to date. Note that the size of total debt also includes public sector debt, including that representing nationalised corporations, and foreign currency debt, as well as gilts in issue. The pattern of steady growth in the size of the debt, and increased expansion in war years, is mirrored in other developed countries. In the post-war period government intervention in the economy and social welfare was also reflected in the size of the debt, as was the effect of inflation in the 1970s, which resulted in a greater nominal value of debt. Perhaps a better indicator of the growth of government debt is its value as a proportion of domestic product. As a percentage this was highest at the end of the second World War, and had been declining since. The 1998 national debt was a fraction under 50% of UK gross domestic product that year.

As the gilt market forms the cornerstone of the sterling asset markets, the gilt yield curve is the benchmark for banks and corporates when setting interest rates and borrowing funds. As is common in many countries, government bonds in the UK form the largest sector within the UK bond markets; in March 1998 the nominal value outstanding of £291 billion comprised just over 57% of the total nominal value of UK bonds. This figure was also larger than the total volume of sterling Eurobonds in issue at that time, approximately £200 billion. The remainder was made up of domestic bonds such as *debentures* and *bulldogs*.

Gilts were one of the strongest performing government bond markets in 1997 and 1998 and yields fell across the curve through 1998, reaching their lowest levels since the mid-1950s. For instance yields on the 30-year benchmark gilt, the 6% Treasury 2028, fell by 120 basis points to 4.5 per cent, roughly the same level as the 10-year benchmark gilt and a lower yield than the 10-year US Treasury benchmark. Gilts also outperformed equities in 1998 and again in 2002. In 1998/99 the government issued £8.2 billion of gilts and issued £17.3 billion of gilts in 1999/00.

Figure 1.1 is an extract from the *Financial Times* for 16 August 2002, showing prices and yields for the liquid conventional and index-linked gilts in issue.

Figure 1.2 (a) shows the King & Shaxson Bond Brokers Limited page “KSBB” as it appears on Bloomberg; this was the page for 19 August 2002. King & Shaxson is a leading broker in the gilts market. The page shows closing prices for the leading stocks. It also shows the gross redemption yield at the indicated price and the change on the previous day’s closing price. Figure 1.2 (b) shows the benchmark stocks only.

In the following chapters we will look at the instruments and institutional practice of the gilt market in greater detail.

<sup>5</sup> These and other fascinating facts are to be found in David Sinclair’s splendid book *The Pound*, published by Century (2000).

<sup>6</sup> Source: DMO (1999).

UK GILTS - cash market																									
Aug 15	Yield			52 week		Yield			52 week		Yield			52 week											
Notes	Int	Red	Price £	+ or -	High	Low	Notes	Int	Red	Price £	+ or -	High	Low	Notes	Int	Red	Price £	+ or -	High	Low					
<b>Shorts* (Lives up to Five Years)</b>																									
Tr 9¼pc '02	9.73	4.20	100.17	-02	104.98	100.17	Tr 8½pc '07	7.26	4.59	117.01	-75	120.39	113.96	Cons 4pc	4.71	-	80.99	-1.90	85.72	71.57					
Tr 8pc '02-6	7.96	3.87	100.55	-03	120.76	100.55	Tr 7¾pc '07	6.45	4.80	112.37	-78	115.11	108.88	War 10 3¼pc	4.94	-	74.31	-1.61	78.34	65.09					
Ex 9pc '02	8.88	3.85	101.30	-04	105.38	101.30	Tr 5pc '09	4.90	4.60	101.97	-75	102.72	99.48	Tr 3¼pc '01 Alt	4.41	-	79.31	-1.50	83.95	88.83					
Tr 11¼pc '03-7	11.38	3.98	103.29	-08	109.87	103.29	Tr 5½pc '08-12	5.24	4.56	104.96	-67	107.03	100.96	Tr 3pc '06 Alt	5.29	-	56.71	-1.26	59.81	50.52					
On 9¼pc '03	9.39	4.10	103.99	-11	108.86	103.99	Tr 8pc '08	7.32	4.66	122.97	-92	127.06	119.44	Cons 2½pc	4.84	-	51.66	-1.25	54.76	45.55					
Tr 6pc '03	7.74	3.77	103.36	-12	106.39	103.29	Tr 4¾pc '10	5.39	4.85	105.77	-92	109.01	102.29	Tr 2½pc	4.88	-	51.49	-1.02	54.36	45.81					
Tr 10pc '03	9.40	3.96	106.33	-17	110.70	106.21	On 9pc Ln '11	6.86	4.69	131.11	-115	136.49	126.13												
Tr 12½pc '03-5	11.32	3.94	110.44	-21	116.69	110.44																			
Tr 6½pc '03	6.30	3.95	103.22	-21	105.24	102.41	<b>Ten to Fifteen Years</b>																		
Tr 13½pc '04-8	11.78	4.03	114.63	-31	121.09	114.39	Tr 7¼pc '12-15	6.37	4.86	121.64	-109	125.65	116.44	Index-Linked (b)											
Tr 10pc '04	9.10	4.09	109.90	-28	114.62	109.35	Tr 5pc '12	4.87	4.66	102.62	-101	105.10	97.47	2½pc '05	(78.8)	-	0.83	222.23	-04	222.27	216.46				
Tr 5pc '04	4.92	4.02	101.69	-29	102.52	99.74	Tr 8pc '13	6.79	4.87	128.62	-128	132.78	122.42	4½pc '04	(135.8)	1.12	1.87	134.76	-04	135.77	132.09				
Fnd 3½pc '99-4	3.53	3.98	99.13	-24	99.47	95.80	Tr 5pc '14	4.85	4.57	103.01	-116	104.17	100.76	2pc '06	(69.5)	1.75	2.05	248.28	-13	248.41	239.71				
On 9½pc '04	8.58	4.20	110.97	-39	114.79	109.99	Tr 8pc '15	6.04	4.69	132.54	-142	137.03	125.28	2½pc '05	(78.8)	2.04	2.22	223.20	-18	223.38	214.88				
Tr 6¼pc '04	6.40	4.20	105.47	-38	107.61	103.75	<b>Over Fifteen Years</b>																		
On 9½pc '05	8.92	4.37	112.80	-46	116.82	111.97	Ex 12pc '13-17	7.33	4.69	163.64	-155	170.34	156.67	2½pc '11	(74.6)	2.11	2.25	236.41	-17	236.74	226.77				
Tr 8½pc '05	8.57	4.45	112.33	-54	115.68	110.29	Tr 8pc '21	6.11	4.71	143.19	-160	146.65	134.98	2½pc '13	(89.2)	2.11	2.22	199.95	-20	199.86	189.65				
Tr 7¾pc '06	8.93	4.53	111.84	-63	114.60	109.11	Tr 5pc '25	4.72	4.39	105.87	-165	110.38	97.11	2½pc '16	(81.6)	2.07	2.18	219.64	-11	221.48	207.56				
On 9¼pc '06	8.14	4.55	119.85	-67	123.81	117.24	Tr 8pc '29	4.91	4.54	122.24	-191	127.99	117.75	2½pc '20	(83.0)	2.04	2.12	220.01	-10	222.24	205.33				
Tr 7½pc '06	6.73	4.53	111.51	-67	114.24	108.68	Tr 4¼pc '32	4.42	4.49	96.06	-170	101.44	86.77	2½pc '24	(97.7)	1.99	2.26	190.79	-06	193.89	178.91				
															4½pc '30	(135.1)	1.96	2.02	184.92	-38	190.15	171.84			
															2pc '35	(173.6)	1.91	1.96	100.32	-31	100.63	94.06			

Source: Debt Management Office (DMO). All UK Gilts are tax-free to non-residents on application, xd Ex dividend. Closing mid-prices are shown in pounds per £100 nominal of stock. Int yield: Interest yield. Red yield: Gross redemption yield. Prospective real Index-Linked redemption yields are calculated by HSBC Bank plc from GEMMA closing prices. \* Indicative price. Gilts "runners", the benchmarks and most liquid stocks, are shown in bold type.

Figure 1.1: UK gilts prices, 16 August 2002. © Financial Times. Used with permission.

UK Gilt Prices					
Full List	Close	Current	Change	Gry	Time
1 UKT 3½ 02	100.120	106.126		3.51	16:00
2 UKT 8 03	103.290	103.290		3.81	16:40
3 UKT 10 03	106.230	105.230		3.96	16:40
4 UKT 5½ 03	103.150	103.150		3.98	16:40
5 UKT 5 04	101.610	101.610		4.06	16:40
6 UKT 6¾ 04	105.350	105.350		4.24	16:24
7 UKT 5½ 05	112.630	112.630		4.42	16:24
8 UKT 6½ 05	112.150	112.150		4.45	16:24
9 UKT 7½ 06	111.640	111.640		4.57	16:24
10 UKT 8 02/06	100.490	100.490		3.82	16:40
11 UKT 7½ 06	111.320	111.320		4.57	16:24
12 UKT 6½ 07	116.780	116.780		4.64	16:40
13 UKT 7½ 07	117.150	117.150		4.64	16:24
14 UKT 5 08	101.790	101.790		4.63	16:40
15 UKT 5 ¾ 09	106.590	106.590		4.67	16:24

Prices shown are indication only.

\*Important\*

Prices will soon only be available to registered users.  
 Contact KSBB on 020 7776 2630

Australia 61 2 9777 8500 Brazil 5511 3048 4500 Europe 44 20 7330 7500 Germany 49 69 920410  
 Hong Kong 852 2377 6000 Japan 81 3 3201 8900 Singapore 65 212 1000 U.S. 1 212 318 2000 Copyright 2002 Bloomberg L.P.  
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Figure 1.2 (a): King & Shaxson Bond Brokers Ltd, gilts page, 19 August 2002. © Bloomberg L.P. © Old Mutual plc. Used with permission.

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UK Gilt Prices						
Benchmarks	Close	Current	Change	Gry	Time	
0 UKT 7 02						
20 UKT 6½ 03	103.150	103.150		3.98		16:40
20 UKT 6¾ 04	105.350	105.350		4.24		16:24
40 UKT 8½ 05	112.150	112.150		4.49		16:24
50 UKT 7½ 06	111.320	111.320		4.57		16:24
60 UKT 7½ 07	112.150	112.150		4.64		16:24
70 UKT 9 08	123.880	123.880		4.53		8:06
10 UKT 5¾ 09	100.590	100.590		4.67		16:24
90 UKT 9 11	130.850	130.850		4.71		16:24
100 UKT 8 15	132.400	132.400		4.70		16:40

Prices shown are indications only.

\*Important\*

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Please Contact KSBB on 020 7776 2630 to register.

Australia 61 2 9777 8600 Brazil 5511 3048 4500 Europe 44 20 7330 7500 Germany 49 69 920410  
Hong Kong 852 2977 6000 Japan 81 3 3201 8900 Singapore 65 212 1000 U.S. 1 212 318 2000 Copyright 2002 Bloomberg L.P.  
6797-57-1 19-Aug-02 16:53:23



Figure 1.2 (b): King & Shaxson Bond Brokers Ltd, benchmark gilts page, 19 August 2002.

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# Appendices

## Appendix 1.1: List of gilts in issue at 1 June 2002

Conventional gilts	Redemption date	Amount in issue (£m)	Amount held in stripped form (£m)
7% Treasury 2002	7 June 2002	9,000	280
9 <sup>3</sup> / <sub>4</sub> % Treasury 2002	27 August 2002	6,623	–
8% Treasury 2002/2006	5 October 2002	2,064	–
8% Treasury 2003	10 June 2003	7,102	–
10% Treasury 2003	8 September 2003	1,872	–
6 <sup>1</sup> / <sub>2</sub> % Treasury 2003	7 December 2003	8,095	42
5% Treasury 2004	7 June 2004	7,504	7
3 <sup>1</sup> / <sub>2</sub> % Funding 1999/2004	14 July 2004	561	–
6 <sup>3</sup> / <sub>4</sub> % Treasury 2004	26 November 2004	6,597	–
9 <sup>1</sup> / <sub>2</sub> % Conversion 2005	18 April 2005	4,469	–
8 <sup>1</sup> / <sub>2</sub> % Treasury 2005	7 December 2005	10,486	142
7 <sup>3</sup> / <sub>4</sub> % Treasury 2006	8 September 2006	4,000	–
7 <sup>1</sup> / <sub>2</sub> % Treasury 2006	7 December 2006	11,800	215
8 <sup>1</sup> / <sub>2</sub> % Treasury 2007	16 July 2007	4,638	–
7 <sup>1</sup> / <sub>4</sub> % Treasury 2007	7 December 2007	11,100	113
5% Treasury 2008	7 March 2008	3,050	–
5 <sup>1</sup> / <sub>2</sub> % Treasury 2008/2012	10 September 2008	1,000	–
9% Treasury 2008	13 October 2008	5,495	–
5 <sup>3</sup> / <sub>4</sub> % Treasury 2009	7 December 2009	8,937	22
6 <sup>1</sup> / <sub>4</sub> % Treasury 2010	25 November 2010	4,958	–
9% Conversion 2011	12 July 2011	5,396	–
7 <sup>3</sup> / <sub>4</sub> % Treasury 2012/2015	26 January 2012	800	–
5% Treasury 2012	7 March 2012	13,346	0
8% Treasury 2013	27 September 2013	6,100	–
8% Treasury 2015	7 December 2015	7,377	334
8 <sup>3</sup> / <sub>4</sub> % Treasury 2017	25 August 2017	7,751	–
8% Treasury 2021	7 June 2021	16,740	294
5% Treasury 2025	7 March 2025	7,672	–
6% Treasury 2028	7 December 2028	11,756	122
4 <sup>1</sup> / <sub>4</sub> % Treasury 2032	7 June 2032	13,829	82
<b>Undated gilts</b>			
2 <sup>1</sup> / <sub>2</sub> % Treasury	Undated	493	–
3 <sup>1</sup> / <sub>2</sub> % War Loan	Undated	1,939	–
<b>Index-linked gilts</b>			
Index-linked gilts	Redemption date	Amount in issue (£m)	Nominal value including inflation uplift (£m)
2 <sup>1</sup> / <sub>2</sub> % I-L Treasury 2003	20 May 2003	2,700	6,117
4 <sup>3</sup> / <sub>8</sub> % I-L Treasury 2004	21 October 2004	1,300	1,739
2% I-L Treasury 2006	19 July 2006	2,037	5,166

Continued overleaf ►

2½% I-L Treasury 2009	20 May 2009	2,673	5,980
2½% I-L Treasury 2011	23 August 2011	3,942	9,317
2½% I-L Treasury 2013	16 August 2013	4,722	9,327
2½% I-L Treasury 2016	26 July 2016	6,055	13,072
2½% I-L Treasury 2020	16 April 2020	4,668	9,914
2½% I-L Treasury 2024	17 July 2024	5,400	9,744
4⅛% I-L Treasury 2030	22 July 2030	3,171	4,136

<b>*Rump* gilts</b>	<b>Redemption date</b>	<b>Amount in issue (£m)</b>
9½% Conversion 2002	14 June 2002	2
9% Exchequer 2002	19 November 2002	83
11¾% Treasury 2003/2007	22 January 2003	234
9¾% Conversion 2003	7 May 2003	12
12½% Treasury 2003/2005	21 November 2003	152
13½% Treasury 2004/2008	26 March 2004	96
10% Treasury 2004	18 May 2004	20
9½% Conversion 2004	25 October 2004	307
10½% Exchequer 2005	20 September 2005	24
9¾% Conversion 2006	15 November 2006	6
8% Treasury 2009	25 September 2009	393
9% Treasury 2012	6 August 2012	403
12% Exchequer 2013/2017	12 December 2013	58
2½% Annuities	Undated	3
3% Treasury	Undated	53
3½% Conversion	Undated	93
2½% Consolidated	Undated	275
2¾% Annuities	Undated	1
4% Consolidated	Undated	358

Double-dated issues currently trading above par are assumed to be called at first maturity. (Source: DMO).

## Appendix 1.2: Growth of the UK national debt

<b>Year</b>	<b>National debt (£ million)</b>	<b>Year</b>	<b>National debt (£ million)</b>
1694	1.2	1975	45,260
1697	15	1980	95,314
1727	53	1985	158,029
1783	232	1988	197,430
1815	900	1989	197,320
1855	805	1992	214,528
1914	651	1993	248,839
1918	5,872	1994	306,871
1940	7,900	1995	349,163
1945	21,365	1996	390,683
1955	26,934	1997	419,546
1965	30,441	1998	418,431

(Source: DMO 1999).

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## **Selected references and bibliography**

Phillips, P., *The Merrill Lynch Guide to the Gilt-Edged and Sterling Bond Market*, The Book Guild Ltd 1996

Sinclair, D., *The Pound*, Century Publishing 2000

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Where you been? Ain't seen you for weeks...  
Where were you, when I wanted to work...?  
Oh yes, and I feel like giving in...

It's all my fault, yes I'm to blame,  
Ain't got no money, ain't got no fame,  
And that's why I feel like giving in.

– Felt, *Ballad of the Band* 1986

## 2 A Primer on Bond Basics

Those who watch television news bulletins in the UK, both terrestrial and some satellite programmes, will be familiar with the cursory bit, delivered either at the end or during the “business” slot, when the newscaster informs viewers where the main stock market index closed that day and where key foreign exchange rates closed at. There is no mention of bond yields. This is a pity, because government bond yields give a much better and more reliable indication of the economy than stock indices. In the United States though, some television news bulletins do inform the viewer at what yield the Treasury long bond closed at. This recognises that bond prices are affected directly by economic and political events, and yield levels on certain government bonds are fundamental indicators of the economy. The yield level on the US Treasury long bond reflects the market's view on US interest rates, inflation, public sector debt and economic growth. Reporting the bond yield level reflects the importance of the bond market to a country's economy, as important as the level of the equity stock market. Under the same logic, it would make sense if news programmes in the UK started to inform us at what yield the 10-year benchmark gilt yield closed at, and what this represented as a change on say, last week's closing yield.

Bonds and shares form part of the *capital markets*. Shares are *equity capital* while bonds are *debt capital*. So bonds are a form of debt, much like how a bank loan is a form of debt. Unlike bank loans, however, bonds can be *traded* in a market. A bond is a debt capital market instrument issued by a borrower, who is then required to repay to the lender/investor the amount borrowed plus interest, over a specified period of time. Bonds are also known as *fixed income* instruments, or *fixed interest* instruments in the sterling markets. Usually bonds are considered to be those debt securities with terms to maturity of over one year. Debt issued with a maturity of less than one year is considered to be *money market* debt. There are many different types of bonds that can be issued. The most common bond is the *conventional* (or *plain vanilla* or *bullet*) *bond*. This is a bond paying regular (annual or semi-annual) interest at a fixed rate over a fixed period to maturity or redemption, with the return of *principal* (the par or nominal value of the bond) on the maturity date. All other bonds will be variations on this.

A bond is therefore a financial contract, in effect an IOU, from the person or body that has issued the bond. Unlike shares or equity capital, bonds carry no ownership privileges. An investor who has purchased a bond and thereby lent money to an institution will have



no voice in the affairs of that institution and no vote at the annual general meeting. The bond remains an interest-bearing obligation of the issuer until it is repaid, which is usually the maturity date of the bond. The issuer can be anyone from a private individual to a sovereign government.

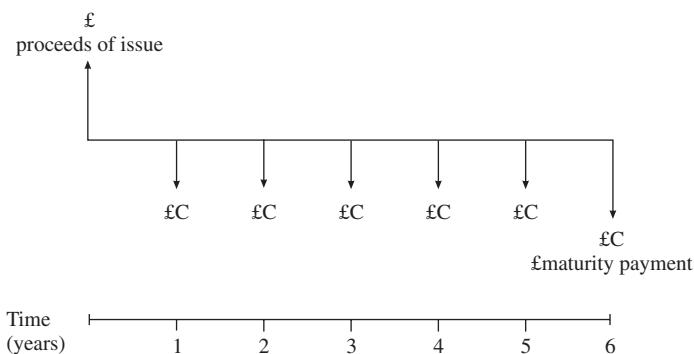
There is a wide range of participants involved in the bond markets. We can group them broadly into borrowers and investors, plus the institutions and individuals who are part of the business of bond trading. Borrowers access the bond markets as part of their financing requirements; hence borrowers can include sovereign governments, local authorities, public sector organisations and corporates. Virtually all businesses operate with a financing structure that is a mixture of debt and equity finance. The debt finance may well contain a form of bond finance, so it is easy to see what an important part of the global economy the bond markets are.

The different types of bonds in the market reflect the different types of issuers and their respective requirements. Some bonds are safer investments than others. The advantage of bonds to an investor is that they represent a fixed source of current income, with an assurance of repayment of the loan on maturity. Bonds issued by developed country governments are deemed to be guaranteed investments in that the final repayment is virtually certain. In the event of default of the issuing entity, bondholders rank above shareholders for compensation payments. There is lower risk associated with bonds compared to shares as an investment, and therefore almost invariably a lower return in the long term.

We can now look in more detail at some important features of bonds.

## 2.1 Description

We have said that a bond is a debt instrument, usually paying a fixed rate of interest over a fixed period of time. Therefore a bond is a collection of cash flows and this is illustrated at Figure 2.1. In our hypothetical example the bond is a six-year issue that pays fixed interest payments of  $C\%$  of the *nominal* value on an annual basis. In the sixth year there is a final interest payment and the loan proceeds represented by the bond are also paid back, known as the maturity proceeds. The amount raised by the bond issuer is a function of the price of the bond at issue, which we have labelled here as the issue proceeds.



**Figure 2.1:** Cash flows associated with a six-year annual coupon bond.

The upward facing arrow represents the cash flow paid and the downward facing arrows are the cash flows received by the bond investor. The cash flow diagram for a six-year bond that had a 5% fixed interest rate, known as a 5% *coupon*, would show interest payments of £5 per every £100 of bonds, with a final payment of £105 in the sixth year, representing the last coupon payment and the redemption payment. Again, the amount of funds raised per £100 of bonds depends on the price of the bond on the day it is first issued, and we will look further into this later. If our example bond paid its coupon on a semi-annual basis, the cash flows would be £2.50 every six months until the final redemption payment of £102.50.

Let us examine some of the key features of bonds.

### 2.1.1 *Type of issuer*

A primary distinguishing feature of a bond is its issuer. The nature of the issuer will affect the way the bond is viewed in the market. There are four issuers of bonds: sovereign governments and their agencies, local government authorities, supranational bodies such as the World Bank, and corporations. Within the corporate bond market there is a wide range of issuers, each with differing abilities to satisfy their contractual obligations to investors. The largest bond markets are those of sovereign borrowers, the government bond markets. The United Kingdom government issues *gilts*. In the United States government bonds are known as *Treasury Notes* and *Treasury Bonds*, or simply *Treasuries*.

### 2.1.2 *Term to maturity*

The *term to maturity* of a bond is the number of years after which the issuer will repay the obligation. During the term the issuer will also make periodic interest payments on the debt. The *maturity* of a bond refers to the date that the debt will cease to exist, at which time the issuer will redeem the bond by paying the principal. The practice in the market is often to refer simply to a bond's "term" or "maturity". The provisions under which a bond is issued may allow either the issuer or investor to alter a bond's term to maturity after a set notice period, and such bonds need to be analysed in a different way. The term to maturity is an important consideration in the make-up of a bond. It indicates the time period over which the bondholder can expect to receive the coupon payments and the number of years before the principal will be paid in full. The bond's *yield* also depends on the term to maturity. Finally, the price of a bond will fluctuate over its life as yields in the market change and as it approaches maturity. As we will discover later, the *volatility* of a bond's price is dependent on its maturity; assuming other factors constant, the longer a bond's maturity the greater the price volatility resulting from a change in market yields.

### 2.1.3 *Principal and coupon rate*

The *principal* of a bond is the amount that the issuer agrees to repay the bondholder on the maturity date. This amount is also referred to as the *redemption value*, *maturity value*, *par value* or *face amount*, or simply *par*. The *coupon rate* or *nominal rate* is the interest rate that the issuer agrees to pay each year. The annual amount of the interest payment made is called the *coupon*. The coupon rate multiplied by the principal of the bond provides the cash amount of the coupon. For example a bond with a 7% coupon rate and a principal of £1,000,000 will pay annual interest of £70,000. In the United Kingdom, United States and

Japan the usual practice is for the issuer to pay the coupon in two semi-annual instalments. For bonds issued in European markets and the Eurobond market coupon payments are made annually. On rare occasions one will encounter bonds that pay interest on a quarterly basis. All bonds make periodic interest payments except for *zero-coupon bonds*. These bonds allow a holder to realise interest by being sold substantially below their principal value. The bonds are redeemed at par, with the interest amount then being the difference between the principal value and the price at which the bond was sold. We will explore zero-coupon bonds in greater detail later.

### 2.1.4 Currency

Bonds can be issued in virtually any currency. The largest volume of bonds in the global markets is denominated in US dollars; other major bond markets are denominated in euros, Japanese yen and sterling, and liquid markets also exist in Australian, New Zealand and Canadian dollars, Swiss francs and other major currencies. The currency of issue may impact on a bond's attractiveness and liquidity which is why borrowers in developing countries often elect to issue in a currency other than their home currency, for example dollars, as this will make it easier to place the bond with investors. If a bond is aimed solely at a country's domestic investors it is more likely that the borrower will issue in the home currency.

## 2.2 Bond issuers

### 2.2.1 Issuers and participants

In most countries government expenditure exceeds the level of government income received through taxation. This shortfall is made up by government borrowing and bonds are issued to finance the government's debt. The core of any domestic capital market is usually the government bond market, which also forms the benchmark for all other borrowing.

Gilts are identified by their coupon rate and year of maturity; they are also given names such as *Treasury* or *Exchequer*. There is no significance attached to any particular name – all gilts are equivalent irrespective of their name. From Figure 1.1 in Chapter 1 we see that the  $5\frac{3}{4}\%$  2009 stock closing price from the day before was 106.77, which means £106.77 of par value. (Remember that par is the lump sum paid at maturity.) This price represents a *gross redemption yield* of 4.65%. If we pay £106.77 per £100 of stock today, we will receive £100 per £100 of stock on maturity. At first sight this appears to imply we will lose money, however we also receive coupon payments every six months, which for this bond is £2.875 per £100 nominal of stock. Also from Figure 1.1 we see the change in price from the day before for each gilt; in the case of the  $5\frac{3}{4}\%$  2009 the price was down 0.92 from the previous day's closing price.

Government agencies also issue bonds. Such bonds are virtually as secure as government bonds. In the United States agencies include the Federal National Mortgage Association. Local authorities issue bonds as part of financing for roads, schools, hospitals and other capital projects.

Corporate borrowers issue bonds both to raise finance for major projects and also to cover ongoing and operational expenses. Corporate finance is a mixture of debt and equity and a specific capital project will often be financed as a mixture of both.

### 2.2.2 *Capital market participants*

The debt capital markets exist because of the financing requirements of governments and corporates. The source of capital is varied, but the total supply of funds in a market is made up of personal or household savings, business savings and increases in the overall money supply. Growth in the money supply is a function of the overall state of the economy, and interested readers may wish to consult the reference list at the end of this chapter which includes several standard economic texts. Individuals save out of their current income for future consumption, while business savings represent retained earnings. The entire savings stock represents the capital available in a market. As we saw in the preface, however, the requirements of savers and borrowers differ significantly, in that savers have a short-term investment horizon while borrowers prefer to take a longer-term view. The “constitutional weakness” of what would otherwise be unintermediated financial markets led, from an early stage, to the development of financial intermediaries.

#### *Financial intermediaries*

In its simplest form a financial intermediary is a *broker* or *agent*. Today we would classify the broker as someone who acts on behalf of the borrower or lender, buying or selling a bond as instructed. However intermediaries originally acted between borrowers and lenders in placing funds as required. A broker would not simply on-lend funds that have been placed with it, but would accept deposits and make loans as required by its customers. This resulted in the first banks.

A *retail bank* deals mainly with the personal financial sector and small businesses, and in addition to loans and deposits also provides cash transmission services. A retail bank is required to maintain a minimum cash reserve, to meet potential withdrawals, but the remainder of its deposit base can be used to make loans. This does not mean that the total size of its loan book is restricted to what it has taken in deposits: loans can also be funded in the wholesale market.

An *investment bank* will deal with governments, corporates and institutional investors. Investment banks perform an agency role for their customers and are the primary vehicle through which a corporate will borrow funds in the bond markets. This is part of the bank’s corporate finance function. It will also act as wholesaler in the bond markets, a function known as *market making*. The bond issuing function of an investment bank, by which the bank will issue bonds on behalf of a customer and pass the funds raised to this customer, is known as *origination*. Investment banks will also carry out a range of other functions for institutional customers, including export finance, corporate advisory and fund management. Other financial intermediaries will trade not on behalf of clients but for their own *book*. These include *arbitrageurs* and speculators. Usually such market participants form part of investment banks.

#### *Investors*

There is a large variety of players in the bond markets, each trading some or all of the different instruments available to suit their own purposes. We can group the main types of investors according to the time horizon of their investment activity.

##### *Short-term institutional investors*

These include banks and building societies, money market fund managers, central banks and the treasury desks of some types of corporates. Such bodies are driven by short-term

investment views, often subject to close guidelines, and will be driven by the total return available on their investments. Banks will have an additional requirement to maintain *liquidity*, often in fulfilment of regulatory authority rules, by holding a proportion of their assets in the form of easily-tradeable short-term instruments.

#### *Long-term institutional investors*

Typically these types of investors include pension funds and life assurance companies. Their investment horizon is long-term, reflecting the nature of their liabilities. Often they will seek to match these liabilities by holding long-dated bonds.

#### *Mixed horizon institutional investors*

This is possibly the largest category of investors and will include general insurance companies and most corporate bodies. Like banks and financial sector companies, they are also very active in the primary market, issuing bonds to finance their operations.

#### *Market professionals*

This category includes the banks and specialist financial intermediaries mentioned above, firms that one would not automatically classify as “investors” although they will also have an investment objective. Their time horizon will range from one day to the very long-term. They include the proprietary trading desks of investment banks, as well as bond market makers in securities houses and banks who are providing a service to their customers. Proprietary traders will actively position themselves in the market in order to gain trading profit, for example in response to their view on where they think interest rate levels are headed. These participants will trade direct with other market professionals and investors, or via brokers. Market makers or *traders* (also called *dealers* in the United States) are wholesalers in the bond markets; they make two-way prices in selected bonds. Firms will not necessarily be active market makers in all types of bonds; smaller firms often specialise in certain sectors. In a two-way quote the *bid price* is the price at which the market maker will buy stock, so it is the price the investor will receive when selling stock. The *offer price* or *ask price* is the price at which investors can buy stock from the market maker. As one might expect the bid price is always higher than the offer price, and it is this *spread* that represents the theoretical profit to the market maker. The bid-offer spread set by the market maker is determined by several factors, including supply and demand, and liquidity considerations for that particular stock, the trader’s view on market direction and *volatility*, as well as that of the stock itself and the presence of any market intelligence. A large bid-offer spread reflects low liquidity in the stock, as well as low demand.

#### **Markets**

Markets are that part of the financial system where capital market transactions, including the buying and selling of securities, takes place. A market can describe a traditional stock exchange, a physical trading floor where securities trading occurs. Many financial instruments are traded over the telephone or electronically over computer links; these markets are known as *over-the-counter* (OTC) markets. A distinction is made between financial instruments of up to one year’s maturity and instruments of over one year’s maturity. Short-term instruments make up the *money market* while all other instruments are deemed to be part of the *capital market*. There is also a distinction made between the *primary market* and the *secondary market*. A new issue of bonds made by an investment bank on behalf of its client is made in the primary market. Such an issue can be a *public* offer, in

which anyone can apply to buy the bonds, or a *private* offer where the customers of the investment bank are offered the stock. The secondary market is the market in which existing bonds and shares are subsequently traded.

## 2.3 World bond markets

The origin of the spectacular increase in the size of global financial markets was the rise in oil prices in the early 1970s. Higher oil prices stimulated the development of a sophisticated international banking system, as they resulted in large capital inflows to developed country banks from the oil-producing countries. A significant proportion of these capital flows were placed in *Eurodollar* deposits in major banks. The growing trade deficit and level of public borrowing in the United States also contributed. The last twenty years has seen tremendous growth in capital markets' volumes and trading. As capital controls were eased and exchange rates moved from fixed to floating, domestic capital markets became internationalised. Growth was assisted by the rapid advance in information technology and the widespread use of financial engineering techniques. Today we would think nothing of dealing in virtually any liquid currency bond in financial centres around the world, often at the touch of a button. Global bond issues, underwritten by the subsidiaries of the same banks, are commonplace. The ease with which transactions can be undertaken has also contributed to a very competitive market in liquid currency assets.

The world bond market has increased in size more than fifteen times in the last thirty years. As at the end of 1999 outstanding volume stood at over \$21 trillion.

The market in US Treasury securities is the largest bond market in the world. Like the government bond markets in the UK, Germany, France and other developed economies, it is also very liquid and transparent. Table 2.1 lists the major government bond markets in the world; the US market makes up nearly half of the total. The Japanese market is second in size, followed by the German market. A large part of the government bond market is concentrated therefore in just a few countries. Government bonds are traded on major exchanges as well as over-the-counter. Generally OTC refers to trades that are not carried out on an exchange but directly between the counterparties. Bonds are also listed on

Country	Nominal value (\$ billion)	Percentage (rounded)
United States	5,490	48.5
Japan	2,980	26.3
Germany	1,236	10.9
France	513	4.5
Canada	335	3.0
United Kingdom	331	2.9
Netherlands	253	2.2
Australia	82	0.7
Denmark	72	0.6
Switzerland	37	0.3
Total	11,329	100

**Table 2.1:** Major government bond markets, December 1999.

Source: IFC 2000.

exchanges, for example the NYSE had over 600 government issues listed on it at the end of 1998, with a total par value of \$2.6 billion.

The corporate bond market varies in liquidity, depending on the currency and type of issuer of any particular bond. Outstanding volume as at the end of 2001 was over \$7.5 trillion. Corporate bonds are also traded on exchanges and OTC. One of the most liquid corporate bond types is the *Eurobond*, which is an international bond issued and traded across national boundaries.

Companies finance their operations in a number of ways, from equity to short-term debt such as bank overdrafts. It is often advantageous for companies to fix longer-term finance, which is why bonds are so popular. Bonds are also attractive as a means of raising finance because the interest payable on them to investors is tax deductible for the company. Dividends on equity are not tax deductible. A corporate needs to get a reasonable mix of debt versus equity in its funding however, as a high level of interest payments will be difficult to service in times of recession or general market downturn. For this reason the market views unfavourably companies that have a high level of debt.

## 2.4 Non-conventional bonds

The definition of bonds given earlier in this chapter referred to conventional or *plain vanilla* bonds. There are many variations on vanilla bonds and we can introduce a few of them here.

### *Floating rate notes*

The bond market is often referred to as the *fixed income* market, or the *fixed interest* market in the UK. Floating rate notes (FRNs) do not have a fixed coupon at all but instead link their interest payments to an external reference, such as the three-month bank lending rate. Bank interest rates will fluctuate constantly during the life of the bond and so an FRN's cash flows are not known with certainty. Usually FRNs pay a fixed margin or *spread* over the specified reference rate; occasionally the spread is not fixed and such a bond is known as a *variable rate note*. Because FRNs pay coupons based on the three-month or six-month bank rate they trade essentially as money market instruments.

### *Index-linked bonds*

An index-linked bond has its coupon and redemption payment, or possibly just either one of these, linked to a specified index. When governments issue index-linked bonds the cash flows are linked to a price index such as consumer or commodity prices. Corporates have issued index-linked bonds that are connected to inflation or a stock market index.

### *Zero-coupon bonds*

Certain bonds do not make any coupon payments at all and these are known as *zero-coupon bonds*. A zero-coupon bond or *strip* only has cash flow, the redemption payment, on maturity. If we assume that the maturity payment is say, £100 per cent or *par* the issue price will be at a discount to par. Such bonds are also known therefore as *discounted* bonds. The difference between the price paid on issue and the redemption payment is the interest realised by the bondholder. As we will discover when we look at strips this has certain advantages for investors, the main one being that there are no coupon payments to be invested during the bond's life. Both governments and corporates issue zero-coupon bonds.

Conventional coupon-bearing bonds can be *stripped* into a series of individual cash flows, which would then trade as separate zero-coupon bonds. This is a common practice in government bond markets such as Treasuries or gilts where the borrowing authority does not actually issue strips, and they have to be created via the stripping process.

### *Securitised bonds*

There is a large market in bonds whose interest and principal liability payments are backed by an underlying cash flow from another asset. By securitising the asset, a borrower can provide an element of cash flow backing to investors. For instance, a mortgage bank can use the cash inflows it receives on its mortgage book as asset backing for an issue of bonds. Such an issue would be known as a mortgage-backed security (MBS). Because residential mortgages rarely run to their full term, but are usually paid off earlier by homeowners, the notes that are backed by mortgages are also prepaid ahead of their legal final maturity. This feature means that MBS securities are not bullet bonds like vanilla securities, but are instead known as *amortising* bonds. Other asset classes that can be securitised include credit card balances, car loans, equipment lease receivables, nursing home receipts, museum or leisure park receipts, and so on.

### *Bonds with embedded options*

Some bonds include a provision in their offer particulars that gives either the bondholder and/or the issuer an option to enforce early redemption of the bond. The most common type of option embedded in a bond is a *call feature*. A call provision grants the issuer the right to redeem all or part of the debt before the specified maturity date. An issuing company may wish to include such a feature as it allows it to replace an old bond issue with a lower coupon rate issue if interest rates in the market have declined. As a call feature allows the issuer to change the maturity date of a bond it is considered harmful to the bondholder's interests; therefore the market price of the bond at any time will reflect this. A call option is included in all asset-backed securities based on mortgages, for obvious reasons (asset-backed bonds are considered in a later chapter). A bond issue may also include a provision that allows the investor to change the maturity of the bond. This is known as a *put feature* and gives the bondholder the right to sell the bond back to the issuer at par on specified dates. The advantage to the bondholder is that if interest rates rise after the issue date, thus depressing the bond's value, the investor can realise par value by *putting* the bond back to the issuer. A *convertible* bond is an issue giving the bondholder the right to exchange the bond for a specified amount of shares (equity) in the issuing company. This feature allows the investor to take advantage of favourable movements in the price of the issuer's shares. The presence of embedded options in a bond makes valuation more complex compared to plain vanilla bonds.

## **2.5 Pricing a conventional bond**

The principles of pricing in the bond market are exactly the same as those in other financial markets, which states that the price of any financial instrument is equal to the net present value today of all the future cash flows from the instrument. A bond price is expressed as per 100 nominal of the bond, or "per cent". So for example if the all-in price of a US dollar denominated bond is quoted as "98.00", this means that for every \$100 nominal of the bond a buyer would pay \$98. The interest rate or discount rate used as part of the present value



(price) calculation is key to everything, as it reflects where the bond is trading in the market and how it is perceived by the market. All the determining factors that identify the bond – those discussed in this chapter and including the type of issuer, the maturity, the coupon and the currency – influence the interest rate at which a bond's cash flows are discounted, which will be roughly similar to the rate used for comparable bonds.

Since the price of a bond is equal to the present value of its cash flows, first we need to know the bond's cash flows before then determining the appropriate interest rate at which to discount the cash flows. We can then compute the price of the bond.

### 2.5.1 *Bond cash flows*

A vanilla bond's cash flows are the interest payments or coupons that are paid during the life of the bond, together with the final redemption payment. It is possible to determine the cash flows with certainty only for conventional bonds of a fixed maturity. So for example, we do not know with certainty what the cash flows are for bonds that have embedded options and can be redeemed early. The coupon payments for conventional bonds are made annually, semi-annually or quarterly. Some bonds pay monthly interest.

Therefore a conventional bond of fixed redemption date is made up of an annuity (its coupon payments) and the maturity payment. If the coupon is paid semi-annually, this means exactly half the coupon is paid as interest every six months. Both gilts and US Treasuries pay semi-annual coupons. For example, the 5% 2012 gilt has the following cash flows:

$$\begin{aligned}\text{Semi-annual coupon} &= \text{£}100 \times 0.025 \\ &= \text{£}2.50\end{aligned}$$

$$\text{Redemption payment} = \text{£}100$$

The bond was issued on 23 June 1999 and is redeemed on 7 March 2012, and pays coupon on 7 March and 7 September each year. So in 2002 the bond is made up of 20 cash flows of £2.50 and one of £100. The time between coupon payments for any bond is counted as 1 period, so there are 20 periods between the first and last cash flows for the gilt in our example. The maturity payment is received 20 periods from today.

### 2.5.2 *The discount rate*

The interest rate that is used to discount a bond's cash flows (therefore called the *discount rate*) is the rate required by the bondholder. It is therefore known as the bond's *yield*. The yield on the bond will be determined by the market and is the price demanded by investors for buying it, which is why it is sometimes called the bond's *return*. The required yield for any bond will depend on a number of political and economic factors, including what yield is being earned by other bonds of the same class. Yield is always quoted as an annualised interest rate, so that for a semi-annually paying bond exactly half of the annual rate is used to discount the cash flows.

### 2.5.3 *Bond pricing*

The *fair price* of a bond is the present value of all its cash flows. Therefore when pricing a bond we need to calculate the present value of all the coupon interest payments and the

present value of the redemption payment, and sum these. The price of a conventional bond that pays annual coupons can therefore be given by (2.1).

$$\begin{aligned}
 P &= \frac{C}{(1+r)} + \frac{C}{(1+r)^2} + \frac{C}{(1+r)^3} + \cdots + \frac{C}{(1+r)^N} + \frac{M}{(1+r)^N} \\
 &= \sum_{n=1}^N \frac{C}{(1+r)^n} + \frac{M}{(1+r)^N}
 \end{aligned} \tag{2.1}$$

where

- $P$  is the price
- $C$  is the annual coupon payment
- $r$  is the discount rate (therefore, the required yield)
- $N$  is the number of years to maturity (therefore, the number of interest periods in an annually-paying bond; for a semi-annual bond the number of interest periods is  $N \times 2$ )
- $M$  is the maturity payment or par value (usually 100 per cent of currency).

For long-hand calculation purposes the first half of (2.1) is usually simplified and in fact can be expressed in two ways as shown by (2.2) below.

$$P = C \left[ \frac{1 - \left[ \frac{1}{(1+r)^N} \right]}{r} \right]$$

or

$$P = \frac{C}{r} \left[ 1 - \frac{1}{(1+r)^N} \right] \tag{2.2}$$

The price of a bond that pays semi-annual coupons is given by the expression at (2.3), which is our earlier expression modified to allow for the twice-yearly discounting:

$$\begin{aligned}
 P &= \frac{\frac{C}{2}}{\left(1 + \frac{1}{2}r\right)} + \frac{\frac{C}{2}}{\left(1 + \frac{1}{2}r\right)^2} + \frac{\frac{C}{2}}{\left(1 + \frac{1}{2}r\right)^3} + \cdots + \frac{\frac{C}{2}}{\left(1 + \frac{1}{2}r\right)^{2N}} + \frac{M}{\left(1 + \frac{1}{2}r\right)^{2N}} \\
 &= \sum_{t=1}^{2N} \frac{\frac{C}{2}}{\left(1 + \frac{1}{2}r\right)^t} + \frac{M}{\left(1 + \frac{1}{2}r\right)^{2N}} \\
 &= \frac{C}{r} \left[ 1 - \frac{1}{\left(1 + \frac{1}{2}r\right)^{2N}} \right] + \frac{M}{\left(1 + \frac{1}{2}r\right)^{2N}}
 \end{aligned} \tag{2.3}$$

Note how we set  $2N$  as the power to which to raise the discount factor, as there are two interest payments every year for a bond that pays semi-annually. Therefore a more

convenient function to use might be the number of interest periods in the life of the bond, as opposed to the number of years to maturity, which we could set as  $n$ , allowing us to alter the equation for a semi-annually paying bond as:

$$P = \frac{C}{r} \left[ 1 - \frac{1}{\left(1 + \frac{1}{2}r\right)^n} \right] + \frac{M}{\left(1 + \frac{1}{2}r\right)^n} \quad (2.4)$$

The formula at (2.4) calculates the fair price on a coupon payment date, so that there is no *accrued interest* incorporated into the price. It also assumes that there is an even number of coupon payment dates remaining before maturity.

The date used as the point for calculation is the *settlement date* for the bond, the date on which a bond will change hands after it is traded. For a new issue of bonds the settlement date is the day when the stock is delivered to investors and payment is received by the bond issuer. The settlement date for a bond traded in the *secondary market* is the day that the buyer transfers payment to the seller of the bond and when the seller transfers the bond to the buyer. Different markets will have different settlement conventions, for example UK gilts normally settle one business day after the trade date (the notation used in bond markets is “T + 1”) whereas Eurobonds settle on T + 3. The term *value date* is sometimes used in place of settlement date, however the two terms are not strictly synonymous. A settlement date can only fall on a business date, so that a gilt traded on a Friday will settle on a Monday. However a value date can sometimes fall on a non-business day, for example when accrued interest is being calculated.

The standard price formula also assumes that the bond is traded for price settlement on a day that is precisely one interest period before the next coupon payment. The price formula is adjusted if dealing takes place between coupon dates. If we take the value date (almost always the settlement date, although unlike the settlement date the value date can fall on a non-working day) for any transaction, we then need to calculate the number of calendar days from this day to the next coupon date. We then use the following ratio  $i$  when adjusting the exponent for the discount factor:

$$i = \frac{\text{Days from value date to next coupon date}}{\text{Days in the interest period}}$$

The number of days in the interest period is the number of calendar days between the last coupon date and the next one, and it will depend on the day count basis used for that specific bond; this is covered in the section on day counts. The price formula is then modified as shown at (2.5),

$$P = \frac{C}{(1+r)^i} + \frac{C}{(1+r)^{1+i}} + \frac{C}{(1+r)^{2+i}} + \dots + \frac{C}{(1+r)^{n-1+i}} + \frac{M}{(1+r)^{n-1+i}} \quad (2.5)$$

where the variables  $C$ ,  $M$ ,  $n$  and  $r$  are as before. Note that (2.5) assumes  $r$  for an annually-paying bond and is adjusted to  $r/2$  for a semi-annually paying bond.

**Example 2.1**

In these examples we illustrate the long-hand price calculation, using both expressions for the calculation of the present value of the annuity stream of a bond's cash flows.

**2.1(a)**

Calculate the fair pricing of a UK gilt, the 9% Treasury 2008, which pays semi-annual coupons, with the following terms:

$$C = \text{£}9.00 \text{ per } \text{£}100 \text{ nominal}$$

$$M = \text{£}100$$

$$N = 10 \text{ years (that is, the calculation is for value on 13 October 1998)}$$

$$r = 4.98\%$$

$$\begin{aligned} P &= \frac{\text{£}9.00}{0.0498} \left\{ 1 - \frac{1}{[1 + \frac{1}{2}(0.0498)]^{20}} \right\} + \frac{\text{£}100}{[1 + \frac{1}{2}(0.0498)]^{20}} \\ &= \text{£}70.2175 + \text{£}61.1463 \\ &= \text{£}131.3638 \end{aligned}$$

The fair price of the gilt is £131.3638, which is composed of the present value of the stream of coupon payments (£70.2175) and the present value of the return of the principal (£61.1463).

**2.1(b)**

What is the price of a 5% coupon sterling bond with precisely 5 years to maturity, with semi-annual coupon payments, if the yield required is 5.40%?

As the cash flows for this bond are 10 semi-annual coupons of £2.50 and a redemption payment of £100 in 10 six-month periods from now, the price of the bond can be obtained by solving the following expression, where we substitute  $C=2.5$ ,  $n=10$  and  $r=0.027$  into the price equation (the values for  $C$  and  $r$  reflect the adjustments necessary for a semi-annual paying bond).

$$\begin{aligned} P &= 2.5 \left[ \frac{1 - \left[ \frac{1}{(1.027)^{10}} \right]}{0.027} \right] + \frac{100}{(1.027)^{10}} \\ &= \text{£}21.65574 + \text{£}76.61178 \\ &= \text{£}98.26752 \end{aligned}$$

The price of the bond is £98.2675 per £100 nominal.

**2.1(c)**

What is the price of a 5% coupon euro bond with five years to maturity paying annual coupons, again with a required yield of 5.40%?

In this case there are five periods of interest, so we may set  $C = 5$ ,  $n = 5$ , with  $r = 0.05$ .

$$\begin{aligned} P &= 5 \left[ \frac{1 - \left[ \frac{1}{(1.054)^5} \right]}{0.054} \right] + \frac{100}{(1.054)^5} \\ &= \text{£}21.410121 + \text{£}76.877092 \\ &= \text{£}98.287213 \end{aligned}$$

Note how the annual-paying bond has a slightly higher price for the same required annualised yield. This is because the semi-annual paying sterling bond has a higher effective yield than the euro bond, resulting in a lower price.

### 2.1(d)

Consider our 5% sterling bond again, but this time the required yield has risen and is now 6%. This makes  $C = 2.5$ ,  $n = 10$  and  $r = 0.03$ .

$$\begin{aligned} P &= 2.5 \left[ \frac{1 - \left[ \frac{1}{(1.03)^{10}} \right]}{0.03} \right] + \frac{100}{(1.03)^{10}} \\ &= \text{£}21.325507 + \text{£}74.409391 \\ &= \text{£}95.734898 \end{aligned}$$

As the required yield has risen, the discount rate used in the price calculation is now higher, and the result of the higher discount is a lower present value (price).

### 2.1(e)

Calculate the price of our sterling bond, still with five years to maturity but offering a yield of 5.10%.

$$\begin{aligned} P &= 2.5 \left[ \frac{1 - \left[ \frac{1}{(1.0255)^{10}} \right]}{0.0255} \right] + \frac{100}{(1.0255)^{10}} \\ &= \text{£}21.823737 + \text{£}77.739788 \\ &= \text{£}99.563525 \end{aligned}$$

To satisfy the lower required yield of 5.10% the price of the bond has fallen to £99.56 per £100.

### 2.1(f)

Calculate the price of the 5% sterling bond one year later, with precisely four years left to maturity and with the required yield still at the original 5.40%. This sets the terms in 2.1(a) unchanged, except now  $n = 8$ .

$$\begin{aligned}
 P &= 2.5 \left[ \frac{1 - \left[ \frac{1}{(1.027)^8} \right]}{0.027} \right] + \frac{100}{(1.027)^8} \\
 &= \text{£}17.773458 + \text{£}80.804668 \\
 &= \text{£}98.578126
 \end{aligned}$$

The price of the bond is £98.58. Compared to 2.1(b) this illustrates how, other things being equal, the price of a bond will approach par (£100 per cent) as it approaches maturity.

### 2.5.4 Pricing undated bonds

There also exist *perpetual* or *irredeemable* bonds which have no redemption date, so that interest on them is paid indefinitely. They are also known as *undated* bonds. An example of an undated bond is the 3½% War Loan, a gilt formed out of issues in 1916 to help pay for the 1914–1918 war effort. Most undated bonds date from a long time in the past and it is unusual to see them issued today. In structure the cash flow from an undated bond can be viewed as a continuous annuity. The fair price of such a bond is given from (2.1) by setting  $N = \infty$ , such that:

$$P = \frac{C}{r} \tag{2.6}$$

where the inputs  $C$  and  $r$  are as before.

### 2.5.5 Bond price quotations

The convention in most bond markets is to quote prices as a percentage of par. The value of par is assumed to be 100 units of currency unless otherwise stated. A sterling bond quoted at an *offer* price of £98.45 means that £100 nominal of the bond will cost a buyer £98.45. A bond selling at below par is considered to be trading at a *discount*, while a price above par means the bond is trading at a *premium* to par. Do not confuse the term trading at a discount with a discount instrument however, which generally refers to a zero-coupon bond.

In most markets bond prices are quoted in decimals, in minimum increments of 1/100ths. This is the case for example with Eurobonds, euro denominated bonds and gilts. Certain markets including the US Treasury market for example, and certain Commonwealth markets such as South African and Indian government bonds quote prices in *ticks*, where the minimum increment is 1/32nd. One tick is therefore equal to 0.03125. A US Treasury might be priced at “98–05” which means “98 and 5 ticks”. This is equal to 98 and 5/32nds which is 98.15625.

#### Example 2.2

- ◆ What is the total consideration for £5 million nominal of a gilt, where the price is 114.50?

The price of the gilt is £114.50 per £100, so the consideration is:

$$1.145 \times 5,000,000 = \text{£}5,725,000$$

- ◆ What consideration is payable for \$5 million nominal of a US Treasury, quoted at an all-in price of 99–16?

The US Treasury price is 99–16, which is equal to 99 and 16/32, or 99.50 per \$100. The consideration is therefore:

$$0.9950 \times 5,000,000 = \$4,975,000$$

If the price of a bond is below par the total consideration is below the nominal amount, whereas if it is priced above par the consideration will be above the nominal amount.

## 2.6 Clean and dirty bond prices

### 2.6.1 *Accrued interest*

Our discussion of bond pricing up to now has ignored coupon interest. All bonds (except zero-coupon bonds) accrue interest on a daily basis, and this is then paid out on the coupon date. The calculation of bond prices using present value analysis does not account for coupon interest or *accrued interest*. In all major bond markets the convention is to quote price as a *clean price*. This is the price of the bond as given by the net present value of its cash flows, but excluding coupon interest that has accrued on the bond since the last dividend payment. As all bonds accrue interest on a daily basis, even if a bond is held for only one day, interest will have been earned by the bondholder. However we have referred already to a bond's *all-in* price, which is the price that is actually paid for the bond in the market. This is also known as the *dirty price* (or *gross price*), which is the clean price of a bond plus accrued interest. In other words the accrued interest must be added to the quoted price to get the total consideration for the bond.

Accruing interest compensates the seller of the bond for giving up all of the next coupon payment even though they will have held the bond for part of the period since the last coupon payment. The clean price for a bond will move with changes in market interest rates; assuming that this is constant in a coupon period, the clean price will be constant for this period. However the dirty price for the same bond will increase steadily from one interest payment date until the next one. On the coupon date the clean and dirty prices are the same and the accrued interest is zero. Between the coupon payment date and the next *ex-dividend* date the bond is traded *cum dividend*, so that the buyer gets the next coupon payment. The seller is compensated for not receiving the next coupon payment by receiving accrued interest instead. This is positive and increases up to the next *ex-dividend* date, at which point the dirty price falls by the present value of the amount of the coupon payment. The dirty price at this point is below the clean price, reflecting the fact that accrued interest is now negative. This is because after the *ex-dividend* date the bond is traded “*ex-dividend*”; the seller not the buyer receives the next coupon and the buyer has to be compensated for not receiving the next coupon by means of a lower price for holding the bond.

The net interest accrued since the last ex-dividend date is determined as follows:

$$AI = C \times \frac{N_{xt} - N_{xc}}{\text{Day Base}} \quad (2.7)$$

where

$AI$	is the next accrued interest
$C$	is the bond coupon
$N_{xc}$	is the number of days between the ex-dividend date and the coupon payment date (7 business days for UK gilts)
$N_{xt}$	is the number of days between the ex-dividend date and the date for the calculation
Day Base	is the day count base (usually 365 or 360).

Interest accrues on a bond from and including the last coupon date up to and excluding what is called the *value date*. The value date is almost always the *settlement* date for the bond, or the date when a bond is passed to the buyer and the seller receives payment. Interest does not accrue on bonds whose issuer has subsequently gone into default. Bonds that trade without accrued interest are said to be trading *flat* or *clean*. By definition therefore,

$$\text{Clean price of a bond} = \text{Dirty price} - AI.$$

For bonds that are trading ex-dividend, the accrued coupon is negative and would be subtracted from the clean price. The calculation is given by (2.8) below.

$$AI = -C \times \frac{\text{Days to next coupon}}{\text{Day Base}} \quad (2.8)$$

Certain classes of bonds, for example US Treasuries and Eurobonds, do not have an ex-dividend period and therefore trade cum dividend right up to the coupon date.

## 2.6.2 Accrual day count conventions

The accrued interest calculation for a bond is dependent on the day-count basis specified for the bond in question. We have already seen that when bonds are traded in the market the actual consideration that changes hands is made up of the clean price of the bond together with the accrued that has accumulated on the bond since the last coupon payment; these two components make up the dirty price of the bond. When calculating the accrued interest, the market will use the appropriate day-count convention for that bond. A particular market will apply one of five different methods to calculate accrued interest; these are:

actual/365	Accrued = Coupon $\times$ days/365
actual/360	Accrued = Coupon $\times$ days/360
actual/actual	Accrued = Coupon $\times$ days/actual number of days in the interest period
30/360	See below
30E/360	See below



Market	Coupon frequency	Day count basis	Ex-dividend period
Australia	Semi-annual	actual/actual	Yes
Austria	Annual	actual/actual	No
Belgium	Annual	actual/actual	No
Canada	Semi-annual	actual/actual	No
Denmark	Annual	actual/actual	Yes
Eurobonds	Annual	30/360	No
France	Annual	actual/actual	No
Germany	Annual	actual/actual	No
Eire	Annual	actual/actual	No
Italy	Annual	actual/actual	No
New Zealand	Semi-annual	actual/actual	Yes
Norway	Annual	actual/365	Yes
Spain	Annual	actual/actual	No
Sweden	Annual	30E/360	Yes
Switzerland	Annual	30E/360	No
United Kingdom	Semi-annual	actual/actual	Yes
United States	Semi-annual	actual/actual	No

**Table 2.2:** Government bond market conventions.

When determining the number of days in between two dates, include the first date but not the second; thus, under the actual/365 convention, there are 37 days between 4 August and 10 September. The last two conventions assume 30 days in each month, so for example there are “30 days” between 10 February and 10 March. Under the 30/360 convention, if the first date falls on the 31st, it is changed to the 30th of the month, and if the second date falls on the 31st and the first date is on the 30th or 31st, the second date is changed to the 30th. The difference under the 30E/360 method is that if the second date falls on the 31st of the month it is automatically changed to the 30th.

The day count basis, together with the coupon frequency, of selected major government bond markets around the world is given in Table 2.2.

### Example 2.3

#### *Accrual calculation for 7% Treasury 2002*

This gilt has coupon dates of 7 June and 7 December each year. £100 nominal of the bond is traded for value on 27 August 1998. What is the accrued interest on the value date?

On the value date 81 days have passed since the last coupon date. Under the old system for gilts, act/365, the calculation was:

$$7 \times \frac{81}{365} = 1.55342.$$

Under the current system of act/act, which came into effect for gilts in November 1998, the accrued calculation uses the actual number of days between the two coupon dates, giving us:

$$7 \times \frac{81}{183} \times 0.5 = 1.54918.$$

**Example 2.4**

Mansur buys £25,000 nominal of the 7% 2002 gilt for value on 27 August 1998, at a price of 102.4375. How much does he actually pay for the bond?

The clean price of the bond is 102.4375. The dirty price of the bond is:

$$102.4375 + 1.55342 = 103.99092$$

The total consideration is therefore  $1.0399092 \times 25,000 = \text{£}25,997.73$ .

**Example 2.5**

A Norwegian government bond with a coupon of 8% is purchased for settlement on 30 July 1999 at a price of 99.50. Assume that this is 7 days before the coupon date and therefore the bond trades ex-dividend. What is the all-in price?

$$\text{The accrued interest} = -8 \times \frac{7}{365} = -0.153424$$

The all-in price is therefore  $99.50 - 0.1534 = 99.3466$ .

## 2.7 Market yield

We referred in Section 2.5.2 to the yield that is “required” by the market at any one time. Just as there are many different types of bond and many different types of borrower, so there are different types of yield. The price of any bond will change in line with changes in required yield, so that straight away we can see that it is not price changes that we are really interested in, but yields. It is a change in required yield that will drive a change in price.<sup>1</sup> So in the bond market we are concerned with examining the determinants of market yields.

The main quoted yield in any market is the government bond yield. This is the yield on a domestic market’s government bonds. The required yield on these bonds is mainly a function of the central bank’s *base rate* or *minimum lending rate*, set by the government or central bank. Other factors will also impact the yield, including the relative size of the public sector budget deficit and national debt as a percentage of the national product (usually measured as Gross Domestic Product or Gross National Product), the economic policies that are adopted, and of course supply and demand for government bonds themselves. A change in any of these factors can and does affect government bond prices. While it is common to view government bonds as the safest credit for investors, this really only applies to the largest developed country markets. Certain countries within the Organisation

<sup>1</sup> We have observed how the price of a bond will gradually converge towards par as it approaches maturity, irrespective of the price it trades at during its life. However this is an automatic process and a mechanical price change that is part of the properties of a bond. As such it need not concern us unduly.

for Economic Co-operation and Development (OECD), for example, Greece, South Korea and Mexico, do not have their government debt given the highest possible rating by credit analysts.

Bonds issued by non-sovereign borrowers will be priced off government bonds, which means that the yields required on them will be at some level above their respective government bond yields, if they are domestic currency bonds. Bond yields are often quoted as a *yield spread* over the equivalent government bond. This is known as the *credit spread* on a bond. A change in the required credit spread for any bond will affect the bond's price. Credit spreads will fluctuate for a variety of reasons, including when there is a change in the way the borrower is perceived in the market (such as a poor set of financial results by a corporate), which will affect the rate at which the borrower can raise funds. Credit spreads can sometimes change because comparable bonds yields change, as well as due to supply and demand factors and liquidity factors.

### 2.7.1 Yield measurement

Bonds are generally traded on the basis of their prices but because of the complicated patterns of cash flows that different bonds can have, they are generally compared in terms of their yields. This means that a market-maker will usually quote a two-way price at which they will buy or sell a particular bond, but it is the yield at which the bond is trading that is important to the market-maker's customer. This is because a bond's price does not actually tell us anything useful about what we are getting. Remember that in any market there will be a number of bonds with different issuers, coupons and terms to maturity. Even in a homogenous market such as the gilt market, different gilts will trade according to their own specific characteristics. To compare bonds in the market therefore we need the yield on any bond and it is yields that we compare, not prices. A fund manager quoted a price at which they can buy a bond will be instantly aware of what yield that price represents, and whether this yield represents fair value. So it is the yield represented by the price that is the important figure for bond traders.

The yield on any investment is the interest rate that will make the present value of the cash flows from the investment equal to the initial cost (price) of the investment. So mathematically the yield on any investment is the interest rate that satisfies our basic bond price equation introduced earlier as equation (2.1).

But as we have noted there are other types of yield measure used in the market for different purposes. The most important of these are bond redemption yields, *spot* rates and *forward* rates. We will now discuss each type of yield measure and show how it is computed, followed by a discussion of the relative usefulness of each measure.

### 2.7.2 Current yield

The simplest measure of the yield on a bond is the *current yield*, also known as the *flat yield*, *interest yield* or *running yield*. The running yield is given by (2.9).

$$rc = \frac{C}{P} \times 100 \quad (2.9)$$

where

- $rc$  is the current yield
- $C$  is the bond coupon
- $P$  is the clean price of the bond.

In (2.9)  $C$  is not expressed as a decimal. Current yield ignores any capital gain or loss that might arise from holding and trading a bond and does not consider the time value of money. It essentially calculates the bond coupon income as a proportion of the price paid for the bond, and to be accurate would have to assume that the bond was more like an annuity rather than a fixed-term instrument.

The current yield is useful as a “rough-and-ready” interest rate calculation; it is often used to estimate the cost of or profit from a short-term holding of a bond. For example if other short-term interest rates such as the one-week or three-month rates are higher than the current yield, holding the bond is said to involve a *running cost*. This is also known as *negative carry* or *negative funding*. The term is used by bond traders and market makers and *leveraged* investors. The *carry* on a bond is a useful measure for all market practitioners as it illustrates the cost of holding or funding a bond. The funding rate is the bondholder’s short-term cost of funds. A private investor could also apply this to a short-term holding of bonds.

### Example 2.6

#### *Running yield*

A bond with a coupon of 6% is trading at a clean price of 97.89. What is the current yield of the bond?

$$\begin{aligned}rc &= \frac{6.00}{97.89} \times 100 \\ &= 6.129\%\end{aligned}$$

### Example 2.7

What is the current yield of a bond with 7% coupon and a clean price of 103.49?

$$\begin{aligned}rc &= \frac{7}{103.49} \times 100 \\ &= 6.76\%\end{aligned}$$

Note from examples 2.6 and 2.7 that the current yield of a bond will lie above the coupon rate if the price of the bond is below par, and vice-versa if the price is above par.

### 2.7.3 Yield to maturity

The *yield to maturity* (YTM) or *gross redemption yield* is the most frequently used measure of return from holding a bond.<sup>2</sup> Yield to maturity takes into account the pattern of coupon payments, the bond’s term to maturity and the capital gain (or loss) arising over the remaining life of the bond. We saw from our bond price in equation (2.1) that these elements were all related and were important components determining a bond’s price. If

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<sup>2</sup> In this book the terms *yield to maturity* and *gross redemption yield* are used synonymously. The latter term is encountered in sterling markets.

we set the IRR for a set of cash flows to be the rate that applies from a start date to an end date we can assume the IRR to be the YTM for those cash flows. The YTM therefore is equivalent to the *internal rate of return* (IRR) on the bond, the rate that equates the value of the discounted cash flows on the bond to its current price. The calculation assumes that the bond is held until maturity and therefore it is the cash flows to maturity that are discounted in the calculation. It also employs the concept of the time value of money.

As we would expect the formula for YTM is essentially that for calculating the price of a bond. For a bond paying annual coupons the YTM is calculated by solving equation (2.10), and we assume that the first coupon will be paid exactly one interest period from now (which, for an annual coupon bond is exactly one year from now).

$$P_d = \frac{C}{(1+rm)^1} + \frac{C}{(1+rm)^2} + \frac{C}{(1+rm)^3} + \dots + \frac{C}{(1+rm)^n} + \frac{M}{(1+rm)^n} \quad (2.10)$$

where

$P_d$	is the bond dirty price
$C$	is the coupon rate
$M$	is the par or redemption payment (100)
$rm$	is the annual yield to maturity (the YTM)
$n$	is the number of interest periods.

Note that the number of interest periods in an annual-coupon bond is equal to the number of years to maturity, and so for these bonds  $n$  is equal to the number of years to maturity.

We can simplify (2.10) using  $\Sigma$  where “ $\Sigma$ ” means “is the sum of”.

$$P_d = \sum_{n=1}^N \frac{C}{(1+rm)^n} + \frac{M}{(1+rm)^n} \quad (2.11)$$

Note that the expression at (2.11) has two variable parameters, the price  $P_d$  and yield  $rm$ . It cannot be re-arranged to solve for yield  $rm$  explicitly and in fact the only way to solve for the yield is to use the process of numerical iteration. The process involves estimating a value for  $rm$  and calculating the price associated with the estimated yield. If the calculated price is higher than the price of the bond at the time, the yield estimate is lower than the actual yield, and so it must be adjusted until it converges to the level that corresponds with the bond price.<sup>3</sup>

For YTM for a semi-annual coupon bond we have to adjust the formula to allow for the semi-annual payments. Equation (2.11) is modified as shown by (2.12), again assuming there are precisely six months to the next coupon payment.

$$P_d = \sum_{n=1}^N \frac{\frac{C}{2}}{\left(1 + \frac{1}{2}rm\right)^n} + \frac{M}{\left(1 + \frac{1}{2}rm\right)^n} \quad (2.12)$$

where  $n$  is now the number of interest periods in the life of the bond and therefore equal to the number of years to maturity multiplied by 2.

<sup>3</sup> Bloomberg<sup>®</sup> also uses the term yield-to-workout where “workout” refers to the maturity date for the bond.

All the YTM equations above use  $rm$  to discount a bond's cash flows back to the next coupon payment and then discount the value at that date back to the date of the calculation. In other words  $rm$  is the internal rate of return that equates the value of the discounted cash flows on the bond to the current dirty price of the bond (at the current date). The internal rate of return is the discount rate which, if applied to all of the cash flows will solve for a number that is equal to the dirty price of the bond (its present value). By assuming that this rate will be unchanged for the reinvestment of all the coupon cash flows, and that the instrument will be held to maturity, the IRR can then be seen as the yield to maturity. In effect both measures are identical; the assumption of uniform reinvestment rate allows us to calculate the IRR as equivalent to the redemption yield. It is common for the IRR measure to be used by corporate financiers for project appraisal, while the redemption yield measure is used in bond markets. The solution to the equation for  $rm$  cannot be found analytically and has to be solved through numerical iteration, that is, by estimating the yield from two trial values for  $rm$ , then solving by using the formula for linear interpolation. It is more common nowadays to use a spreadsheet programme or programmable calculator such as a Hewlett-Packard calculator.

Note that the redemption yield as discussed in this section is the gross redemption yield, the yield that results from payment of coupons without deduction of any withholding tax. The *net redemption yield* is obtained by multiplying the coupon rate  $C$  by  $(1 - \text{marginal tax rate})$ . The net yield is what will be received if the bond is traded in a market where bonds pay coupon net, which means net of a withholding tax. The net redemption yield is always lower than the gross redemption yield.

#### 2.7.4 Using the redemption yield calculation

We have already alluded to the key assumption behind the YTM calculation, namely that the rate  $rm$  remains stable for the entire period of the life of the bond. By assuming the same yield we can say that all coupons are reinvested at the same yield  $rm$ . For the bond in example 2.8 this means that if all the cash flows are discounted at 6.5% they will have a total present value or NPV of 97.89. At the same time if all the cash flows received during the life of the bond are reinvested at 6.5% until the maturity of the bond, the final redemption yield will be 6.5%. This is patently unrealistic since we can predict with virtual certainty that interest rates for instruments of similar maturity to the bond at each coupon date will not remain at 6.5% for five years.

In practice, however, investors require a rate of return that is equivalent to the price that they are paying for a bond and the redemption yield is, to put it simply, as good a measurement as any. A more accurate measurement might be to calculate present values of future cash flows using the discount rate that is equal to the market's view on where interest rates will be at that point, known as the *forward* interest rate. However forward rates are *implied* interest rates, and a YTM measurement calculated using forward rates can be as speculative as one calculated using the conventional formula. This is because the actual market interest rate at any time is invariably different from the rate implied earlier in the forward markets. So a YTM calculation made using forward rates would not be realised in practice either.<sup>4</sup> We shall see later in this chapter how the *zero-coupon* interest rate is the

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<sup>4</sup> Such an approach is used to price interest-rate swaps, however.

true interest rate for any term to maturity. However the YTM is, despite the limitations presented by its assumptions, the main measure of return used in the markets.

### Example 2.8

#### *Comparing the different yield measures*

The examples in this section illustrated a five-year bond with a coupon of 6% trading at a price of 97.89. Using the three common measures of return we have:

Running yield	= 6.129%
Simple yield	= 6.560%
Redemption yield	= 6.50%

## 2.8 Bond pricing and yield

The approach we have described is very much the traditional one. Academic texts express bond prices and yields in different terms, which we consider briefly now. The terminology is that used in leading texts including Jarrow (1996), Neftci (1996), Baxter and Rennie (1996) and Hull (1997).

Consider a zero-coupon bond that has a maturity date at time  $T$ . The price of this bond today (at time  $t$ ) is denoted by  $P(t, T)$  and given by (2.13) below,

$$P(t, T) = \frac{1}{[r(t, T)]^{(T-t)}} \quad (2.13)$$

where  $r(t, T)$  is the yield of the  $T$ -maturity bond at time  $t$ . Expression (2.13) above can be re-written as follows, in terms of the bond yield.

$$r(t, T) = \left[ \frac{1}{P(t, T)} \right]^{1/(T-t)} \quad (2.14)$$

This states that the yield on the zero-coupon bond is the percentage return earned in the period from the time the bond is held ( $t$ ) to its maturity date  $T$ .

We can then derive an expression for the bond price in terms of a *forward rate*. The forward rate  $rf(t, T)$  is the rate that applies at time  $t$  for the period  $(T, T+1)$  and is given by (2.15) below,

$$rf(t, T) = \frac{P(t, T)}{P(t, T+1)} \quad (2.15)$$

and is the interest-rate that is earned on a deposit over the time period  $(T, T+1)$  that has been put on at time  $t$ . Expression (2.1) above may be used to obtain a formula for the price of a bond, given below.

$$P(t, T) = \frac{1}{\prod_{j=t}^{T-1} rf(t, j)} \quad (2.16)$$

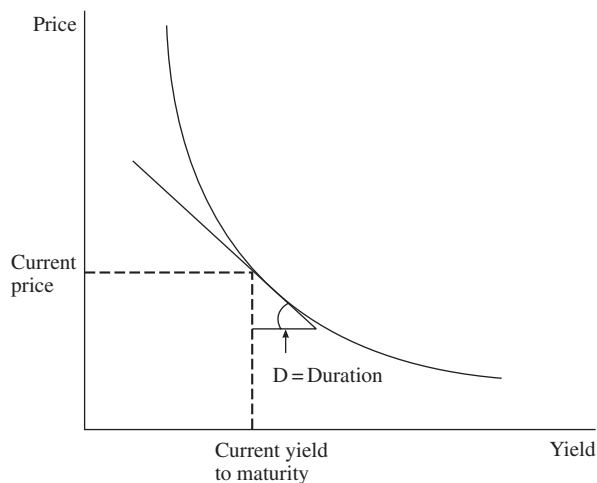
Expression (2.16) states the price of a bond in terms of the forward rates for maturity periods up to the maturity of the bond itself. For a zero-coupon bond the price is the

present value of 1 that is received at time  $T$ , discounted at the forward rates that apply to each interest period from  $t$  to the maturity date. This is the bond price expression found in later texts. In fact the bond price is usually given in terms of an *integral* of forward rates, because rates are analysed as occurring in a *continuous time* environment. This is an advanced area of bond mathematics and interested readers should consult the texts listed in the bibliography. The derivation of (2.16) is given in Jarrow (1996) and other texts.

## 2.9 The price/yield relationship

This chapter has illustrated a fundamental property of bonds, namely that an upward change in the price results in a downward move in the yield, and vice-versa. This is of course immediately apparent since the price is the present value of the cash flows; as the required yield for a bond say decreases, the present value and hence the price of the cash flow for the bond will increase. It also reflects the fact that for plain vanilla bonds the coupon is fixed, therefore it is the price of the bond that will need to fluctuate to reflect changes in market yields. It is useful sometimes to plot the relationship between yield and price for a bond. A typical price/yield profile is represented graphically at Figure 2.2, which shows a *convex* curve.

To reiterate, for a plain vanilla bond with a fixed coupon, the price is the only variable that can change to reflect changes in the market environment. When the coupon rate of a bond is equal to the market rate, the bond price will be par (100). If the required interest rate in the market moves above a bond's coupon rate at any point in time, the price of the bond will adjust downward in order for the bondholder to realise the additional return required. Similarly if the required yield moves below the coupon rate, the price will move up to equate the yield on the bond to the market rate. As a bond will redeem at par, the capital appreciation realised on maturity acts as compensation when the coupon rate is lower than the market yield.



**Figure 2.2:** The bond price/yield relationship.



The price of a bond will move for a variety of reasons, including the market-related ones noted here:

- when there is a change in the yield required by the market, either because of changes in the base rate or a perceived change in credit quality of the bond issuer (credit considerations do not affect developed country government bonds);
- when there is a change because as the bond is approaching maturity, its price moves gradually towards par;
- when there is a change in the market-required yield due to a change in the yield on comparable bonds.

Bond prices also move for liquidity reasons and normal supply-and-demand reasons, for example if there is a large amount of a particular bond in issue it is easier to trade the bond; also if there is demand due to a large customer base for the bond. Liquidity is a general term used here to mean the ease with which a market participant can trade in or out of a position. If there is always a ready buyer or seller for a particular bond, it will be easier to trade in the market.

Table 2.3 shows the prices for a hypothetical 7% coupon, quoted for settlement on 10 August 1999 and maturing on 10 August 2004. The bond pays annual coupons on a 30/360 basis. The prices are calculated by inserting the required yield values into the standard formulae for a set of cash flows. We can calculate the present value of the annuity stream represented by the bond and the present value of the final maturity payment. Note that when the required yield is at the same level as the bond's fixed coupon (in this case 7%) the price of the bond is 100 per cent, or *par*.

### 2.9.1 *Coupon, yield and price relationship*

The bond markets are also known as the “fixed income” or “fixed interest” markets. This reflects the fact that the coupon for conventional bonds is fixed, and in most cases the

Yield (%)	Price
4.0	113.3555
4.5	110.9750
5.0	108.6590
5.5	106.4054
6.0	104.2124
6.5	102.0778
<b>7.0</b>	<b>100.0000</b>
7.5	97.9770
8.0	96.0073
8.5	94.0890
9.0	92.2207
9.5	90.4007
10.0	88.6276

**Table 2.3:** Prices and yields for a 7% five-year bond.

maturity date is also fixed. Therefore when required yield levels in the market change, the price is the only factor that can change to reflect the new market yield levels. We saw in Table 2.3 how the price of our hypothetical 7% five-year bond changed as the required yield changed. This is an important result. Let us consider the situation – if the required yield in the market for our 7% bond is fixed, investors will be happy to hold the bond. What if required yields subsequently rise above the 7% level? Bondholders will be unhappy as they are now being paid 7% when elsewhere in the market higher yields are available. The market price of the bond will therefore change so that the yield on the bond changes, to compensate bondholders. If the required yield for the bond changes to 8%, we see from Table 2.3 that the price has fallen from par to 96.00. If this did not happen bondholders would sell the 7% issue and buy a bond that was yielding 8%; the market price mechanism ensures that this does not happen. If the situation is reversed the price mechanism will again operate to equalise the yield on the bond with those prevalent in the marketplace. If required yields drop to 6% the bond price rises to 104.21, because bondholders would now be receiving 7% when yields available in the market are now only 6%. We can see then that when required yield in the market is equal to a bond's coupon, the bond price will be par; the price will move respectively above or below par if required yields are below or above the coupon rate.

If a bond is priced at below its par value it is said to be trading at a *discount*, while if it is trading above par value it is said to be trading at a *premium* to its par value.

When merchant banks issue bonds on behalf of borrowers, they will set a bond's coupon at the level that would make the bond price equal to par. This means that the bond coupon will be equal to the yield required by the market at the time of issue. The bond's price would then fluctuate as market yields changed, as we showed in Table 2.3. Investors generally prefer to pay par or just under par when they buy a new issue of bonds, which is why a merchant bank will set the coupon that equates the bond price to par or in a range between 99.00 and par. The reason behind this preference to pay no more than par is often purely cosmetic, since an issue price above par would simply indicate a coupon higher than the market rate. However, as many fund managers and investors buy a bond and hold it until maturity, one often finds this prejudice against paying over par for a new issue.

What will happen if market yields remain unchanged during the life of a bond from when it was issued? In this unlikely scenario the price of a conventional bond will remain unchanged at par. The price of any bond will ultimately equal its redemption value, which is par. Therefore a bond that is priced at a premium or a discount will gradually converge to par as it approaches maturity.

As a bond approaches maturity there are fewer and fewer coupon payments, so that progressively more of the bond's price is made up of the present value of the final redemption payment. The present value of this payment will steadily increase as the maturity date is approached, since it is being discounted over a shorter period of time. The present value of the annuity cash flows of the bond steadily declines as we get fewer of them, and this is not offset by the increase in value of the maturity payment. Hence the price of the bond steadily declines. The opposite happens when the bond price starts off at a discount, where the increase in the value of the maturity payment outweighs the decrease in the price of the coupons, so that the bond price steadily converges to par.

**Example 2.9*****Illustration of price/yield changes for two selected gilts***

Prices of selected gilts on 14 July 1999 for next-day settlement

UK Treasury stock 5% 2004

Price	Yield %
98.61750	5.324
98.64875	5.317
98.68000	5.309 (actual quoted price at the time of asking)
98.71100	5.302
98.74200	5.295

UK Treasury stock 5¾% 2009

Price	Yield %
104.73750	5.155
104.76875	5.151
104.80000	5.147 (actual quoted price at the time of asking)
104.83125	5.143
104.86250	5.140

**2.10 Duration, modified duration and convexity**

Bonds pay a part of their total return during their lifetime, in the form of coupon interest, so that the term to maturity does not reflect the true period over which the bond's return is earned. Additionally if we wish to gain an idea of the trading characteristics of a bond, and compare this to other bonds of say, similar maturity, term to maturity is insufficient and so we need a more accurate measure. A plain vanilla coupon bond pays out a proportion of its return during the course of its life, in the form of coupon interest. If we were to analyse the properties of a bond, we should conclude quite quickly that its maturity gives us little indication of how much of its return is paid out during its life, nor any idea of the timing or size of its cash flows, and hence its sensitivity to moves in market interest rates. For example, if comparing two bonds with the same maturity date but different coupons, the higher coupon bond provides a larger proportion of its return in the form of coupon income than does the lower coupon bond. The higher coupon bond provides its return at a faster rate; its value is theoretically therefore less subject to subsequent fluctuations in interest rates.

We may wish to calculate an average of the time to receipt of a bond's cash flows, and use this measure as a more realistic indication of maturity. However, cash flows during the life of a bond are not all equal in value, so a more accurate measure would be to take the average time to receipt of a bond's cash flows, but weighted in the form of the cash flows' present value. This is, in effect, *duration*. We can measure the speed of payment of a bond, and hence its price risk relative to other bonds of the same maturity by measuring the average maturity of the bond's cash flow stream. Bond analysts use duration to measure this property (it is sometimes known as *Macaulay's duration*, after its inventor, who first

introduced it in 1938).<sup>5</sup> Duration is the weighted average time until the receipt of cash flows from a bond, where the weights are the present values of the cash flows, measured in years. At the time that he introduced the concept, Macaulay used the duration measure as an alternative for the length of time that a bond investment had remaining to maturity.

### 2.10.1 Duration

Recall that the price/yield formula for a plain vanilla bond is as given at (2.17) below, assuming complete years to maturity paying annual coupons, and with no accrued interest at the calculation date. The yield to maturity reverts to the symbol  $r$  in this section.

$$P = \frac{C}{(1+r)} + \frac{C}{(1+r)^2} + \frac{C}{(1+r)^3} + \cdots + \frac{C}{(1+r)^n} + \frac{M}{(1+r)^n} \quad (2.17)$$

If we take the first derivative of this expression we obtain (2.18).

$$\frac{dP}{dr} = \frac{(-1)C}{(1+r)^2} + \frac{(-2)C}{(1+r)^3} + \cdots + \frac{(-n)C}{(1+r)^{n+1}} + \frac{(-n)M}{(1+r)^{n+1}} \quad (2.18)$$

If we re-arrange (2.18) we will obtain the expression at (2.19), which is our equation to calculate the approximate change in price for a small change in yield.

$$\frac{dP}{dr} = -\frac{1}{(1+r)} \left[ \frac{1C}{(1+r)} + \frac{2C}{(1+r)^2} + \cdots + \frac{nC}{(1+r)^n} + \frac{nM}{(1+r)^n} \right] \quad (2.19)$$

Readers may feel a sense of familiarity regarding the expression in brackets in equation (2.19) as this is the weighted average time to maturity of the cash flows from a bond, where the weights are the present values of each cash flow. The expression at (2.19) gives us the approximate measure of the change in price for a small change in yield. If we divide both sides of (2.19) by  $P$  we obtain the expression for the approximate percentage price change, given at (2.20).

$$\frac{dP}{dr} \frac{1}{P} = -\frac{1}{(1+r)} \left[ \frac{1C}{(1+r)} + \frac{2C}{(1+r)^2} + \cdots + \frac{nC}{(1+r)^n} + \frac{nM}{(1+r)^n} \right] \frac{1}{P} \quad (2.20)$$

If we divide the bracketed expression in (2.20) by the current price of the bond  $P$  we obtain the definition of Macaulay duration, given at (2.21).

$$D = \frac{\frac{1C}{(1+r)} + \frac{2C}{(1+r)^2} + \cdots + \frac{nC}{(1+r)^n} + \frac{nM}{(1+r)^n}}{P} \quad (2.21)$$

Equation (2.21) is simplified using  $\Sigma$  notation as shown by (2.22).

$$D = \frac{\sum_{n=1}^N \frac{nC_n}{(1+r)^n}}{P} \quad (2.22)$$

where  $C$  represents the bond cash flow at time  $n$ .

<sup>5</sup> Macaulay, F., *Some theoretical problems suggested by the movements of interest rates, bond yields and stock prices in the United States since 1865*, National Bureau of Economic Research, NY 1938. Although frequently quoted, it's rare to meet someone who has actually read this work. However, it remains a fascinating treatise and is well worth reading; it is available from Risk Classics publishing, under the title *Interest rates, bond yields and stock prices in the United States since 1856*.

Example 2.10 calculates the Macaulay duration for a hypothetical bond, an 8% 2009 annual coupon bond.

### Example 2.10

Calculating the Macaulay duration for an 8% 2009 annual coupon bond

Issued	30 September 1999
Maturity	30 September 2009
Price	102.497
Yield	7.634%

Period ( $n$ )	Cash flow	PV at current yield*	$n \times PV$
1	8	7.43260	7.4326
2	8	6.90543	13.81086
3	8	6.41566	19.24698
4	8	5.96063	23.84252
5	8	5.53787	27.68935
6	8	5.14509	30.87054
7	8	4.78017	33.46119
8	8	4.44114	35.529096
9	8	4.12615	37.13535
10	108	51.75222	517.5222
Total		102.49696	746.540686

\* Calculated as  $C/(1+r)^n$ .

Macaulay Duration =  $746.540686/102.497 = 7.283539998$  years.

Modified Duration =  $7.28354/1.07634 = 6.76695$ .

**Table 2.4:** Duration calculation for the 8% 2009 bond.

The Macaulay duration value given by (2.22) is measured in years. An interesting observation by Galen Burghardt in *The Treasury Bond Basis* is that, “measured in years, Macaulay’s duration is of no particular use to anyone.” (Burghardt 1994, page 90). This is essentially correct. However, as a risk measure and hedge calculation measure, duration transformed into *modified duration* was the primary measure of interest rate risk used in the markets, and is still widely used despite the advent of the *value-at-risk* measure for market risk.

If we substitute the expression for Macaulay duration (2.21) into equation (2.20) for the approximate percentage change in price we obtain (2.23) below.

$$\frac{dP}{P} \frac{1}{dr} = - \frac{1}{(1+r)} D \quad (2.23)$$

This is the definition of modified duration, given as (2.24).

$$MD = \frac{D}{(1+r)} \quad (2.24)$$

Modified duration is clearly related to duration then, in fact we can use it to indicate that, for small changes in yield, a given change in yield results in an inverse change in bond price. We can illustrate this by substituting (2.24) into (2.23), giving us (2.25).

$$\frac{dP}{dr} \frac{1}{P} = -MD \quad (2.25)$$

If we are determining duration long-hand, there is another arrangement we can use to shorten the procedure. Instead of equation (2.17) we use (2.26) as the bond price formula, which calculates price based on a bond being comprised of an annuity stream and a redemption payment, and summing the present values of these two elements. Again we assume an annual coupon bond priced on a date that leaves a complete number of years to maturity and with no interest accrued.

$$P = C \left[ \frac{1 - \frac{1}{(1+r)^n}}{r} \right] + \frac{M}{(1+r)^n} \quad (2.26)$$

This expression calculates the price of a bond as the present value of the stream of coupon payments and the present value of the redemption payment. If we take the first derivative of (2.26) and then divide this by the current price of the bond  $P$ , the result is another expression for the modified duration formula, given at (2.27).

$$MD = \frac{\frac{C}{r^2} \left[ 1 - \frac{1}{(1+r)^n} \right] + \frac{n(M-C)}{(1+r)^{n+1}}}{P} \quad (2.27)$$

We have already shown that modified duration and duration are related; to obtain the expression for Macaulay duration from (2.27) we multiply it by  $(1+r)$ . This short-hand formula is demonstrated in Example 2.11 for a hypothetical bond, the annual coupon 8% 2009.

### Example 2.11

8% 2009 bond: using equation (2.27) for the modified duration calculation

Coupon	8%, annual basis
Yield	7.634%
$n$	10
Price	102.497

Substituting the above terms into the equation we obtain:

$$\begin{aligned} MD &= \frac{\frac{8}{(0.07634^2)} \left[ 1 - \frac{1}{(1.07634)^{10}} \right] + \frac{10(100 - \frac{8}{0.07634})}{(1.07634)^{11}}}{102.497} \\ &= 6.76695 \end{aligned}$$

To obtain the Macaulay duration we multiply the modified duration by  $(1+r)$ , in this case 1.07634, which gives us a value of 7.28354 years.

For an irredeemable bond duration is given by:

$$D = \frac{1}{rc} \quad (2.28)$$

where  $rc = (C/P_d)$  is the *running yield* (or *current yield*) of the bond. This follows from equation (2.22) as  $N \rightarrow \infty$ , recognising that for an irredeemable bond  $r = rc$ . Equation (2.28) provides the limiting value to duration. For bonds trading at or above par duration increases with maturity and approaches this limit from below. For bonds trading at a discount to par duration increases to a maximum at around 20 years and then declines towards the limit given by (2.28). So in general, duration increases with maturity, with an upper bound given by (2.28).

### 2.10.2 Properties of Macaulay duration

A bond's duration is always less than its maturity. This is because some weight is given to the cash flows in the early years of the bond's life, which brings forward the average time at which cash flows are received. In the case of a zero-coupon bond, there is no present value weighting of the cash flows, for the simple reason that there are no cash flows, and so duration for a zero-coupon bond is equal to its term to maturity. Duration varies with coupon, yield and maturity. The following three factors imply higher duration for a bond:

- the lower the coupon;
- the lower the yield;
- broadly, the longer the maturity.

Duration increases as coupon and yield decrease. As the coupon falls, more of the relative weight of the cash flows is transferred to the maturity date and this causes duration to rise. Because the coupon on index-linked bonds is generally much lower than on vanilla bonds, this means that the duration of index-linked bonds will be much higher than for vanilla bonds of the same maturity. As yield increases, the present values of all future cash flows fall, but the present values of the more distant cash flows fall relatively more than those of the nearer cash flows. This has the effect of increasing the relative weight given to nearer cash flows and hence of reducing duration.

#### *The effect of the coupon frequency*

Certain bonds such as Eurobonds pay coupon annually compared to say, gilts which pay semi-annual coupons. If we imagine that every coupon is divided into two parts, with one part paid a half-period earlier than the other, this will represent a shift in weight to the left, as part of the coupon is paid earlier. Thus, increasing the coupon frequency shortens duration, and of course decreasing coupon frequency has the effect of lengthening duration.

#### *Duration as maturity approaches*

Using our definition of duration we can see that initially it will decline slowly, and then at a more rapid pace as a bond approaches maturity.

#### *Duration of a portfolio*

Portfolio duration is a weighted average of the duration of the individual bonds. The weights are the present values of the bonds divided by the full price of the entire portfolio, and the

resulting duration calculation is often referred to as a “market-weighted” duration. This approach is in effect the duration calculation for a single bond. Portfolio duration has the same application as duration for an individual bond, and can be used to structure an *immunised* portfolio.

### 2.10.3 Modified duration

Although it is common for newcomers to the market to think intuitively of duration much as Macaulay originally did, as a proxy measure for the time to maturity of a bond, such an interpretation is to miss the main point of duration, which is a measure of price volatility or interest rate risk.

Using the first term of a Taylor’s expansion of the bond price function<sup>6</sup> we can show the following relationship between price volatility and the duration measure, which is expressed as (2.29) below.

$$\Delta P = - \left[ \frac{1}{(1+r)} \right] \times \text{Macaulay duration} \times \text{Change in yield} \quad (2.29)$$

where  $r$  is the yield to maturity for an annual-paying bond (for a semi-annual coupon bond, we use  $r/2$ ). If we combine the first two components of the right-hand side, we obtain the definition of modified duration. Equation (2.29) expresses the approximate percentage change in price as being equal to the modified duration multiplied by the change in yield. We saw in the previous section how the formula for Macaulay duration could be modified to obtain the *modified duration* for a bond. There is a clear relationship between the two measures. From the Macaulay duration of a bond can be derived its modified duration, which gives a measure of the sensitivity of a bond’s price to small changes in yield. As we have seen, the relationship between modified duration and duration is given by (2.30).

$$MD = \frac{D}{1+r} \quad (2.30)$$

where  $MD$  is the modified duration in years. However, it also measures the approximate change in bond price for a 1% change in bond yield. For a bond that pays semi-annual coupons, the equation becomes:

$$MD = \frac{D}{1 + \frac{1}{2}r} \quad (2.31)$$

This means that the following relationship holds between modified duration and bond prices:

$$\Delta P = MD \times \Delta r \times P \quad (2.32)$$

In the UK markets the term *volatility* is sometimes used to refer to modified duration but this is becoming increasingly uncommon in order to avoid confusion with option markets’ use of the same term, which there often refers to *implied volatility* and is something different.

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<sup>6</sup> For an accessible explanation of the Taylor expansion, see Butler, C., *Mastering Value-at-Risk*, FT Prentice Hall 1998, pp. 112–114.



**Example 2.12****Using modified duration**

An 8% annual coupon bond is trading at par with a duration of 2.74 years. If yields rise from 8% to 8.50%, then the price of the bond will fall by:

$$\begin{aligned}\Delta P &= -D \times \frac{\Delta r}{1+r} \times P \\ &= -(2.74) \times \left( \frac{0.005}{1.080} \right) \times 100 \\ &= -\pounds 1.2685\end{aligned}$$

That is, the price of the bond will now be  $\pounds 98.7315$ .

The modified duration of a bond with a duration of 2.74 years and yield of 8% is obviously:

$$MD = \frac{2.74}{1.08}$$

which gives us  $MD$  equal to 2.537 years.

This tells us that for a 1 per cent move in the yield to maturity, the price of the bond will move (in the opposite direction) by 2.54%.

We can use modified duration to approximate bond prices for a given yield change. This is illustrated with the following expression:

$$\Delta P = -MD \times (\Delta r) \times P \quad (2.33)$$

For a bond with a modified duration of 3.99, priced at par, an increase in yield of 1 basis point (100 basis = 1 per cent) leads to a fall in the bond's price of:

$$\Delta P = (-3.24/100) \times (+0.01) \times 100.00$$

$$\Delta P = \pounds 0.0399, \text{ or } 3.99 \text{ pence}$$

In this case 3.99 pence is the *basis point value* of the bond, which is the change in the bond price given a 1 basis point change in the bond's yield. The basis point value of a bond can be calculated using (2.34).

$$BPV = \frac{MD}{100} \times \frac{P}{100} \quad (2.34)$$

Basis point values are used in hedging bond positions. To hedge a bond position requires an opposite position to be taken in the hedging instrument. So if we are long a 10-year bond, we may wish to sell short a similar 10-year bond as a hedge against it. Similarly a short position in a bond will be hedged through a purchase of an equivalent amount of the hedging instrument. In fact there are a variety of hedging instruments available, both on and off-balance sheet. Once the hedge is put on, any loss in the primary position should in theory be offset by a gain in the hedge position, and vice-versa. The objective of a hedge is to ensure that the price change in the primary instrument is equal to the price change in the hedging instrument. If we are hedging a position with another bond, we use the BPVs of each bond to calculate the amount of the hedging instrument required. This is important

because each bond will have different BPVs, so that to hedge a long position in say £1 million nominal of a 30-year bond does not mean we simply sell £1 million of another 30-year bond. This is because the BPVs of the two bonds will almost certainly be different. Also there may not be another 30-year bond in that particular bond. What if we have to hedge with a 10-year bond? How much nominal of this bond would be required?

We need to know the ratio given at (2.35) to calculate the nominal hedge position.

$$\frac{BPV_p}{BPV_h} \quad (2.35)$$

where

$BPV_p$  is the basis point value of the primary bond (the position to be hedged)  
 $BPV_h$  is the basis point value of the hedging instrument.

The *hedge ratio* is used to calculate the size of the hedge position and is given at (2.36).

$$\frac{BPV_p}{BPV_h} \times \frac{\text{change in yield for primary bond position}}{\text{change in yield for hedge instrument}} \quad (2.36)$$

The second ratio in (2.36) is known as the *yield beta*.

Example 2.13 illustrates using the hedge ratio.

### Example 2.13

#### *Calculating hedge size using basis point value*

A trader holds a long position of £1 million of the 8% 2019 bond. The modified duration of the bond is 11.14692 and its price is 129.87596. The basis point value of this bond is therefore 0.14477. The trader decides, to protect against a rise in interest rates, to hedge the position using the 0% 2009 bond, which has a BPV of 0.05549. If we assume that the yield beta is 1, what nominal value of the zero-coupon bond must be sold in order to hedge the position?

The hedge ratio is:

$$\frac{0.14477}{0.05549} \times 1 = 2.60894.$$

Therefore to hedge £1 million of the 20-year bond the trader shorts £2,608,940 of the zero-coupon bond. If we use the respective BPVs to see the net effect of a 1 basis point rise in yield, the loss on the long position is approximately equal to the gain in the hedge position.

### Example 2.14

#### *The nature of the modified duration approximation*

Table 2.5 shows the change in price for one of our hypothetical bonds, the 8% 2009, for a selection of yields. We see that for a 1 basis point change in yield, the change in price given by the dollar duration figure, while not completely accurate, is a reasonable estimation of the actual change in price. For a large move however, say 200 basis

Bond	Maturity (years)	Modified duration	Price duration of basis point	Yield									
				6.00%	6.50%	7.00%	7.50%	7.99%	8.00%	8.01%	8.50%	9.00%	10.00%
8%	2009 10	6.76695	0.06936	114.72017	110.78325	107.02358	103.43204	100.06713	<b>100.00000</b>	99.93293	96.71933	93.58234	87.71087
				Yield change			Price change			Estimate using price duration			
				down 1 bp			0.06713			0.06936			
				up 1 bp			0.06707			0.06936			
				down 200 bp			14.72017			13.872			
				up 200 bp			12.28913			13.872			

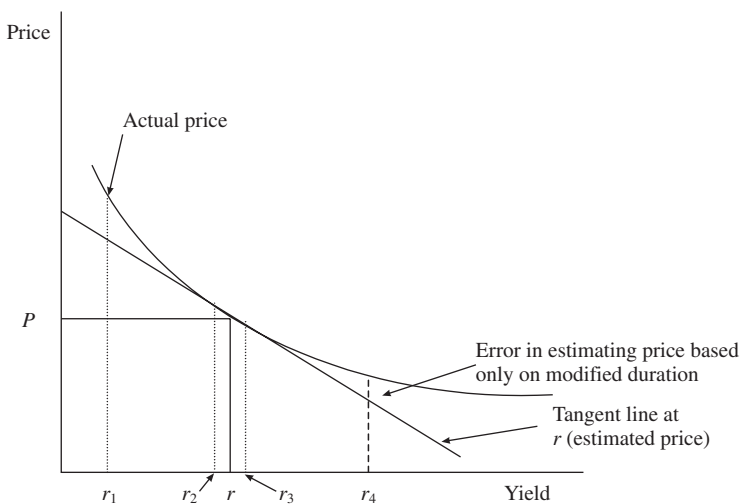
**Table 2.5:** Nature of the modified duration approximation.

points, the approximation is significantly in error and analysts would not use it. Notice also for our hypothetical bond how the dollar duration value, which is the suggested change in cash value resulting from the change in yields calculated from the modified duration measurement, underestimates the change in price resulting from a fall in yields but overestimates the price change for a rise in yields. This is a reflection of the price/yield relationship for this bond. Some bonds will have a more pronounced convex relationship between price and yield and the modified duration calculation will underestimate the price change resulting from both a fall or a rise in yields.

### 2.10.4 Convexity

Duration can be regarded as a first-order measure of interest rate risk: it measures the *slope* of the present value/yield profile. It is, however, only an approximation of the actual change in bond price given a small change in yield to maturity. Similarly for modified duration, which describes the price sensitivity of a bond to small changes in yield. However, as Figure 2.4 illustrates, the approximation is an underestimate of the actual price at the new yield. This is the weakness of the duration measure.

*Convexity* is a second-order measure of interest rate risk; it measures the *curvature* of the present value/yield profile. Convexity can be regarded as an indication of the error we make when using duration and modified duration, as it measures the degree to which the curvature of a bond's price/yield relationship diverges from the straight-line estimation. The convexity of a bond is positively related to the dispersion of its cash flows thus, other things being equal, if one bond's cash flows are more spread out in time than another's, then it will have a higher *dispersion* and hence a higher convexity. Convexity is also positively related to duration.



**Figure 2.3:** Approximation of the bond price change using modified duration.

The second-order differential of the bond price equation with respect to the redemption yield  $r$  is:

$$\begin{aligned}\frac{\Delta P}{P} &= \frac{1}{P} \frac{\Delta P}{\Delta r} (\Delta r) + \frac{1}{2P} \frac{\Delta^2 P}{\Delta r^2} (\Delta r)^2 \\ &= -MD(\Delta r) + \frac{CV}{2} (\Delta r)^2\end{aligned}\quad (2.37)$$

where  $CV$  is the convexity.

From equation (2.37), convexity is the rate at which price variation to yield changes with respect to yield. That is, it describes a bond's modified duration changes with respect to changes in yield. It can be approximated by expression (2.38).

$$CV = 10^8 \left( \frac{\Delta P'}{P} + \frac{\Delta P''}{P} \right) \quad (2.38)$$

where

$\Delta P'$  is the change in bond price if yield increases by 1 basis point (0.01)  
 $\Delta P''$  is the change in bond price if yield decreases by 1 basis point (0.01).

The unit of measurement for convexity using (2.38) is the number of interest periods. For annual coupon bonds this is equal to the number of years; for bonds paying coupon on a different frequency we use (2.39) to convert the convexity measure to years.

$$CV_{years} = \frac{CV}{C^2} \quad (2.39)$$

The convexity measure for a zero-coupon bond is given by (2.40).

$$CV = \frac{n(n+1)}{(1+r)^2} \quad (2.40)$$

Convexity is a second-order approximation of the change in price resulting from a change in yield. This is given by:

$$\Delta P = \frac{1}{2} \times CV \times (\Delta r)^2 \quad (2.41)$$

The reason we multiply the convexity by 1/2 to obtain the convexity adjustment is because the second term in the Taylor expansion contains the coefficient 1/2. The convexity approximation is obtained from a Taylor expansion of the bond price formula. An illustration of Taylor expansion of the bond price/yield equation is given in Appendix 39.3 of the author's book *The Bond and Money Markets*. The formula is the same for a semi-annual coupon bond.

Note that the value for convexity given by the expressions above will always be positive, that is the approximate price change due to convexity is positive for both yield increases and decreases.

Convexity is an attractive property for a bond to have. What level of premium will be attached to a bond's higher convexity? This is a function of the current yield levels in the market as well as market volatility. Remember that modified duration and convexity are functions of yield level, and that the effect of both is magnified at lower yield levels. As well as the relative level, investors will value convexity higher if the current market conditions

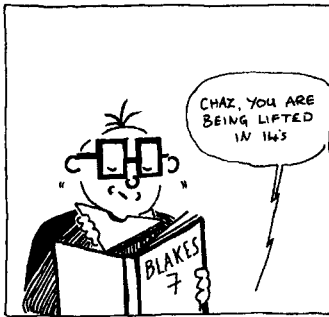
are volatile. Remember that the cash effect of convexity is noticeable only for large moves in yield. If an investor expects market yields to move only by relatively small amounts, they will attach a lower value to convexity; and vice-versa for large movements in yield. Therefore the yield premium attached to a bond with higher convexity will vary according to market expectations of the future size of interest rate changes.

The convexity measure increases with the square of maturity, and it decreases with both coupon and yield. As the measure is a function of modified duration, index-linked bonds have greater convexity than conventional bonds. We discussed how the price/yield profile will be more convex for a bond of higher convexity, and that such a bond will outperform a bond of lower convexity whatever happens to market interest rates. High convexity is therefore a desirable property for bonds to have. In principle a more convex bond should fall in price less than a less convex one when yields rise, and rise in price more when yields fall. That is, convexity can be equated with the potential to outperform. Thus, other things being equal, the higher the convexity of a bond the more desirable it should, in principle, be to investors. In some cases investors may be prepared to accept a bond with a lower yield in order to gain convexity. We noted also that convexity is in principle of more value if uncertainty, and hence expected market volatility, is high, because the convexity effect of a bond is amplified for large changes in yield. The value of convexity is therefore greater in volatile market conditions.

For a conventional vanilla bond convexity is almost always positive. Negative convexity resulting from a bond with a concave price/yield profile would not be an attractive property for a bondholder; the most common occurrence of negative convexity in the cash markets is with callable bonds.

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The only colours permitted were blue or grey, the only variation the width and thickness of the pin stripe . . . Shirts were plain or striped, never check and the button-down collar was for Americans . . . Ties were silk, plain or patterned but pictures on ties were not known and polyester was for the back office, the clearing banks or the insurance companies.

– Philip Augar, *The Death of Gentlemanly Capitalism* 2000

# 3 The Gilt-Edged Market I: Structure and Institutions

## 3.1 Market instruments

### 3.1.1 *Conventional gilts*

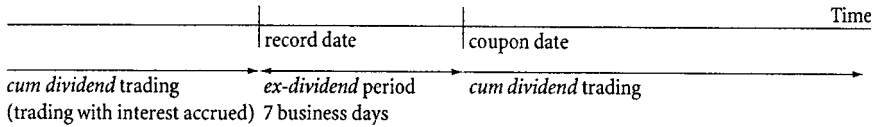
The gilt market is essentially plain vanilla in nature. The majority of gilt issues are conventional fixed interest bonds. Conventional gilts have a fixed coupon and maturity date. By volume they made up 82% of the market in June 2002. Coupon is paid on a semi-annual basis. The coupon rate is set in line with market interest rates at the time of issue, so the range of coupons in existence reflects the fluctuations in market interest rates. Unlike many government and corporate bond markets, gilts can be traded in the smallest unit of currency and sometimes nominal amounts change hands in amounts quoted down to one penny (£0.01) nominal size. Individual gilts are given names such as the 5% Treasury 2012 or the 9% Conversion 2011. There is no significance attached to the name given to a gilt, they are all identical in make-up and credit quality, and they all trade in the same way. Most issues in existence are now “Treasury” issues, although in the past it was sometimes possible to identify the purpose behind the loan by its name. For example a “Conversion” issue usually indicates a bond converted from a previous gilt. The 3½% War Loan on the other hand was issued to help refinance loans raised to help pay for the 1914–18 war. The 3% Gas 1995/98 was issued to finance the nationalisation of the gas industry and was redeemed in 1998.

In Choudhry (2001) a colour plate shows the certificate representing a retail holding of a conventional gilt, the 5% Treasury 2004, which matures on 7 June 2004.

Gilts are registered securities. All gilts pay coupon to the registered holder as at a specified record date; the record date is seven business days before the coupon payment date. The period between the record date and the coupon date is known as the ex-dividend or “ex-div” (“xd”) period; during the ex-dividend period the bond trades without accrued interest. This is illustrated in Figure 3.1.

The ex-dividend period was reduced from three weeks to seven business days for all gilts in 1995; the facility to trade *special ex-div*, which was a two-week period prior to the start of the ex-dividend period during which transactions could be traded ex-div on agreement between buyer and seller, was removed in 1998. The ex-dividend period for one issue, 3½%





**Figure 3.1:** Gilt ex-dividend trading.

War Loan, was retained at three weeks (subsequently reduced to ten business days) due to the large number of retail holders of this bond. Currently there are no floating-rate gilts in existence (the most recent was the floating-rate gilt 2001). The 1999 FRG also had an ex-dividend period.<sup>1</sup>

### 3.1.2 *Double-dated gilts*

Although they have not been issued for over ten years, there are currently eight double-dated gilts in existence, but they represent a small proportion of the market. Double-dated gilts have two maturity dates quoted, and under the terms of issue the government may redeem them on any day between the first and second maturity dates, providing at least three months' notice is given. As with callable bonds in the corporate market, the government will usually redeem a double-dated bond early if it is trading above par, since this indicates that the coupon on the bond is above the prevailing market interest rate. Where the price is below par the bond will be allowed to run to the final redemption date. An example of the latter is the 3½% Funding 1999–2004, which trades well below par and therefore can be expected to run to its final maturity date of 14 July 2004, although the government can redeem it at any point between now and July 2004 if it so wishes, providing it gives at least three months' notice.

Double-dated issues are usually less liquid than conventional or index-linked gilts (I-L gilts), mainly because there is a relatively small amount in issue and also because a larger proportion are held by personal investors. They also tend to have high coupons, reflecting the market rates in existence at the time they were issued.

### 3.1.3 *Floating rate gilts*

In recent years the government has issued conventional floating rate gilts, the last of which matured in March 2001, leaving none in existence at the time of writing. Floating rate gilts paid coupon on a quarterly basis at a rate of LIBID minus 12.5 basis points. The Bank of England (BoE) calculates the coupon level based on the LIBID fixing for the day before the coupon payment is due. The liquidity of floating rate gilts is comparable to conventional gilts.

### 3.1.4 *Gilt strips*

Gilt strips are zero-coupon bonds created from conventional coupon gilts. Only issues actually designated as strippable gilts may be stripped. They are considered in a separate chapter.

<sup>1</sup> The author traded in large size in the floating rate 1999 and was sad to see the last floater gilt pass away...

### 3.1.5 *Undated gilts*

The most esoteric instruments in the gilt market are the undated gilts, also known as *irredeemable* gilts or *consols*. They are very old issues, indeed some date from the nineteenth century.<sup>2</sup> There are eight such issues, and they do not have a maturity date. Redemption is therefore at the discretion of the government. Some undated issues are very illiquid. The largest issue is the 3½% War Loan, with just over £1.9 billion in existence. In the past the BoE undertook conversions of the less liquid irredeemable bonds into War Loan, so that for all but this stock and the 2½% Treasury bond there are only rump amounts remaining. The government can choose to redeem an undated gilt provided a requisite notice period is given (this varies for individual issues but generally is three months), but in practice – given that the coupon on these bonds is very low – it is unlikely to do so unless market interest rates drop below say, 3%. A peculiarity of three of the undated gilts is that they pay interest on a quarterly basis.<sup>3</sup>

### 3.1.6 *Treasury bills*

Strictly speaking Treasury bills (T-Bills) are not part of the gilts market but form part of the sterling money markets. They are short-term government instruments, issued at a discount and redeemed at par. The most common bills are three-month (91-day) maturity instruments, although six-month bills are also issued. In theory any maturity between one-month and twelve-months may be selected. In the past the BoE has issued one-month and six-month bills in addition to the normal three-month maturity bills. Bills are issued via a weekly tender at which anyone may bid; generally clearing banks, building societies and discount houses take an active part in the bill market.

In debt capital markets the yield on a domestic government T-Bill is usually considered to represent the risk-free interest rate, since it is a short-term instrument guaranteed by the government. This makes the T-Bill rate, in theory at least, the most secure investment in the market. It is common to see the three-month T-Bill rate used in corporate finance analysis and option pricing analysis, which often refer to a risk-free money market rate.

The responsibility for bill issuance was transferred to the Debt Management Office (DMO) from the BoE in 1999. The DMO set up a slightly changed framework<sup>4</sup> in order to facilitate continued market liquidity. The main elements of the framework included a wider range of maturities and a larger minimum issue size at each weekly tender, plus a guaranteed minimum stock in issue of £5 billion. The DMO also pre-announces the maturities that will be available in the next quarter's tenders. The settlement of Treasury bills has been fixed at the next working day following the date of the tender.

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<sup>2</sup> For instance the 2½% Annuities gilt was issued in 1853. You won't find too many market makers who are keen to trade in it though!

<sup>3</sup> These are 2½% Consolidated stock, 2½% Annuities and 2¾% Annuities.

<sup>4</sup> This is set out in *The Future of UK Government Cash Management: The New Framework*, Debt Management Office, 4 December 1998. Further detail is contained in the DMO's *Information Memorandum* from September 2001.

### 3.1.7 Maturity breakdown of stock outstanding

Gilts are classified by the DMO and the *Financial Times* as “shorts” if maturing in 0–7 years, “mediums” if maturing in 7–15 years and “longs” if maturing in over 15 years’ time. Gilt-edged market makers (GEMMs) usually apply a different distinction, with shorts being classified as 0–3 years, mediums as 4–10 years and longs as those bonds maturing in over 10 years. Of conventional gilts outstanding, the proportion of shorts:mediums:longs has remained fairly constant in recent years; the ratio was 46:35:19 in 1997, 45:35:20 in 1998, 44:30:26 in 1999 and 45:27:28 in June 2002 (DMO 2002).

By investor the distribution of gilt holdings as at June 2002 is shown below.

Insurance companies and pension funds	61%
Overseas holders	18%
Households	9%
Banks and building societies	2%
Other institutions	9%
Local authorities and public corporations	1%

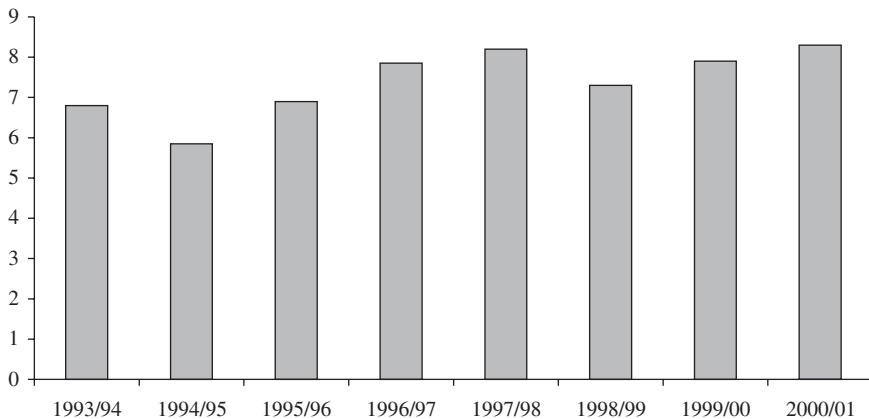
(Source: DMO)

Appendix 3.1 lists statistical data on the gilt portfolio and outstanding volume.

### 3.1.8 Market turnover

Figure 3.2 shows the annual turnover by value in gilts from the fiscal year 1993/94 to 2000/01. Average daily turnover in 2000/01 was £8.3 billion. The chart illustrates a general upward trend in market trading volumes, the trend being reversed temporarily during 1998. This reflects the contraction in global bond market trading in the aftermath of the financial crises of the second half of that year, typified by the technical default in a Russian long-dated bond and the Brazilian currency crisis.

Data on market turnover is published by the London Stock Exchange (LSE) and the DMO on a regular basis.



**Figure 3.2:** Average daily gilt market turnover. (Source: DMO).

### 3.1.9 *Market trading conventions*

Gilts are quoted on a clean price basis, for next day settlement. This is known as “cash” settlement or  $T + 1$ . It is possible to trade for same day settlement (“cash-cash”) if dealing is carried out before mid-day and with the agreement of the market maker. It is also possible to trade for forward settlement. During 1998 there were major changes to gilt market trading conventions designed to bring market conventions into line with major European bond markets. These changes are detailed below.

#### *Price quote*

From 1 November 1998 gilt prices changed from pricing in ticks (1/32 of a point; a tick was therefore equal to 0.03125. The tick price quote is employed in the US Treasury market) to pricing in decimals. Prices are now displayed as £ and pence per cent of stock. Auction bids are to two decimal places, as are GEMM reference prices. The bid-offer spread is very close in the gilt market, reflecting its liquidity and transparency. For bonds up to ten years in maturity it is possible to receive quotes as narrow as £0.01 between bid and offer; at the very short end institutional investors are often able to deal on “choice” prices (when the price for bid and offer is the same) if talking to two GEMMs simultaneously. For long-dated gilts the bid-offer spread can sometimes be as close as £0.06, roughly the equivalent of two ticks.

#### *Daycount convention*

The daycount convention for the calculation of accrued interest was changed from actual/365 to actual/actual, from 1 November 1998. Appendix 3.2 illustrates the difference in calculations that has resulted from this change.

In addition after 31 July 1998 the special ex-dividend period arrangement for gilts was ended. This mechanism had allowed trading whereby up to 21 calendar days prior to the ex-dividend date, the parties to a gilt transaction could agree to trade on an ex-dividend basis (this refers to a trade in which the purchaser takes delivery of the gilts without the right to the next coupon payment). Although special ex-dividend arrangements have now been removed, gilts still automatically trade ex-dividend up to 7 business days before the calendar date (except for War Loan, for which the ex-dividend period was retained at 21 days, since reduced to 10 business days). There is no ex-dividend period for floating rate gilts. Gilt strips trade on a yield basis and of course there is no accrued interest element in the calculation of settlement proceeds in a transaction. The DMO has published a yield-to-price conversion formula, to ensure that a uniform calculation is used by all market participants.

#### *Market screens*

There are a number of news screens associated with the gilt market, which help to make it transparent. The DMO has screens on Reuters, Telerate and Bloomberg. Many GEMMs also post prices of gilts on their own news screens, although some firms only make their screens available to selected customers.<sup>5</sup> Brokers’ screens are usually available to the market as a whole. Prices are indicative only and must be checked on the telephone with the market maker or broker before dealing. A typical broker screen as appearing on Bridge-Telerate, showing mid-prices for benchmark gilts, is shown at Figure 3.3. The

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<sup>5</sup> The author’s screen on Reuters, AAHX, with short-dated gilt prices and sterling money market rates, was for some time still “alive” but is now sadly unavailable!

DESCRIPTION	TIME	MID PX	PX CHG	TRUE YIELD	LIBOR SPREAD
UKT 6	99	7:46	100.0900	—	4.6700 -0.403
UKT 8	00	9:02	104.0700	—	4.9413 -0.569
UKT 7	01	9:06	103.7400	-0.010	5.2590 -0.674
UKT 7	02	9:06	104.4700	-0.010	5.3116 -0.780
UKT 8	03	9:05	109.0000	-0.010	5.4096 -0.834
UKT 6.5	03	9:05	104.3600	—	5.3715 -0.858
UKT 6.75	04	9:06	106.3500	-0.010	5.3699 -0.868
UKT 8.5	05	9:06	116.4900	-0.020	5.4137 -0.825
UKT 7.5	06	9:06	112.4400	+0.010	5.4337 -0.731
UKT 7.25	07	9:06	112.4600	+0.070	5.3846 -0.725
UKT 9	08	9:06	126.4800	+0.040	5.3329 -0.807
UKT 9	12	9:06	135.6400	-0.020	5.2048 -0.857
UKT 8	15	9:06	133.0700	+0.060	5.0143 -0.987
UKT 8	21	9:06	142.1200	+0.010	4.8521 -1.152
UKT 6	28	9:05	120.9400	+0.110	4.6811 -1.096

Figure 3.3: Butlers Gilts screen on 14 July 1999. © Bridge-Telerate. © GarbanICAP 1999. Used with permission.

UKT 5 12 Corp DES

PC01 Corp DES

SECURITY DESCRIPTION

Page 17/1

TREASURY UKT 5 03/07/12 102.4500/102.5100 (4.68/4.67) BGN @11:47

ISSUER INFORMATION	IDENTIFIERS	
Name TSY 5 2012	London 013042586	1) Additional Sec Info
Type Sovereign	ISIN GB0030468747	2) Identifiers
Market of Issue UK GILT STOCK	Sedol 3046874	3) Ratings
SECURITY INFORMATION	RATINGS	
Country GB Currency GBP	Agency NA	4) Sec. Specific News
Collateral Type BONDS	S&P NA	5) Custom Notes
Calc Typ( 26)UK:BUMP/DMO METHOD	Fitc NA	6) Issuer Information
Maturity 3/ 7/2012 Series	ISSUE SIZE	7) ALLQ
NORMAL	Net Issued	8) Pricing Sources
Coupon 5 FIXED	GBP 13,346,466 (M)	9) Prospectus Request
S/A ACT/ACT	Act. Outstanding	10) Related Securities
Announcement Dt 5/15/01	GBP 13,346,466 (M)	
Int. Accrual Dt 5/25/01	Min Piers/Increment	
1st Settle Date 5/25/01	0.01/ 0.01	
1st Coupon Date 9/ 7/01	Per Amount 100.00	
Iss Pr 98.8100	BOOK RUNNER/EXCHANGE	
HAVE PROSPECTUS	LONDON	65) Old DES
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Figure 3.4: Bloomberg page DES, showing details of 5% Treasury 2012, 19 August 2002.

screen also shows the most recent price change, the equivalent yield, and the yield spread to the interest rate swap curve (called the “Libor spread” on the screen shown). A Bloomberg’s screen showing the Treasury 5% 2012 gilt is shown in Figure 3.4.

## 3.2 Taxation

Coupon interest on registered gilts is payable gross, without deduction of withholding tax. Investors who are resident in the United Kingdom for tax purposes are liable to pay tax at their marginal rate on gilt coupons however. Therefore interest received, including the inflation uplift on I-L gilts, is declared on annual tax returns. Bondholders on the BoE register may request that their coupons be paid net of withholding tax.

The tax treatment is summarised below.

### 3.2.1 *Domestic corporate investors*

The interest and capital gain earned on holdings of gilts are liable to tax at the corporate taxation rate. The corporate tax rate in 2001/2002 was 28%, and the tax is payable on a quarterly basis. The accounting treatment for gilt holdings is expected to be in line with the company’s statutory accounts. This will be either a *mark-to-market* or *accruals* basis. In a mark-to-market approach, bonds are valued at their market dirty price on a daily basis; the valuation is the market value that applies at the end of the quarterly accounting period. The total return over the period is then deemed to be the increase in market value in that time. In an accruals approach, bonds are amortised on a clean price basis from the purchase date to maturity. The total return is deemed to be the change in the clean price plus income accrued over the accounting period.

The above applies equally to conventional gilts and gilt strips. For I-L gilts, however, UK corporates are not liable to tax on the inflation uplift earned on the principal payment received on maturity.

### 3.2.2 *Resident private investors*

Individual private investors resident in the UK are liable for income tax on gilt coupon interest received. This includes accrued interest earned during a short-term holding. Capital gain made on a disposal of gilts is not liable to tax. Gains accruing on gilt strips are taxable however, on an annual basis. Strip earnings are taxed as income on an annual basis, irrespective of whether the strip has actually been sold. That is, the tax authorities deem a strip to have been sold and re-purchased at the end of tax year, with any gain taxed as income. A savings vehicle introduced in April 1999, known as an Individual Savings Account (ISA), allows individuals to hold gilts free of both income and capital taxes. There is a limit on the amount that may be held, which is a maximum of £5,000 per annum from tax year 2000/01 onwards. Gilt strips may also be held free of tax within an ISA, within the £5,000 yearly limit.

### 3.2.3 *Overseas investors*

Investors who are resident overseas, both corporate and individual, are exempt from UK tax on gilt holdings. Prior to April 1998 only gilts designated as “Free of Tax to Residents Abroad” (FOTRA) paid gross coupons automatically to overseas residents; however from that date all gilts have been designated FOTRA stocks and thus overseas investors receive gross coupons. Unlike UK equity market transactions, there is no stamp duty or stamp duty reserve tax payable on purchases or sales of gilts.

### 3.3 Market structure

The gilt market operates within the overall investment business environment in the United Kingdom. As such wholesale market participants are regulated by the Financial Services Authority (FSA), the central regulatory authority brought into being by the newly elected Labour government in 1997. The FSA regulates the conduct of firms undertaking business in the gilt market; it also supervises the exchanges on which trading in gilts and gilt derivatives takes place. The previous regulatory regime in the UK markets, as conducted under the Financial Services Act 1986, consisted of market participants being authorised by self-regulatory organisations such as the Securities and Futures Authority (SFA). The FSA was set up initially through merging all the different self-regulatory bodies. Hence gilt market makers and brokers are authorised by the FSA on behalf of the SFA, while firms domiciled in European Union countries are authorised by their domestic regulatory authority. The full formal powers of the FSA were assumed by that body once the Financial Services and Markets Act 2000 came into being.

The gilt market is an “over-the-counter” market, meaning that transactions are conducted over the telephone between market participants. However all individual issues are listed on the London Stock Exchange, which as a Recognised Investment Exchange is also supervised by the FSA.

### 3.4 Market makers and brokers

Just as in the United States and France for example, there is a registered primary dealer system in operation in the UK government bond market. The present structure dates from “Big Bang” in 1986, the large-scale reform of the London market that resulted in the abolition of the old distinction between *jobbers* and *brokers* and allowed firms to deal in both capacities if they so wished; it also resulted in stock and share trading moving off the floor of the Stock Exchange and into the dealing rooms of banks and securities houses. Firms that wished to provide a two-way dealing service and act on their own account registered as gilt-edged market makers. In 1986 there were 29 companies so registered, most of whom were the gilts trading arms of the large banks. Firms registered as GEMMs with the BoE, and until 1998 there was a requirement for GEMMs to be separately capitalised if they were part of a larger integrated banking group. This requirement has since been removed. In September 1999 there were 16 firms registered as GEMMs, who must now be recognised as such by the DMO. The full list is provided at Appendix 3.3. GEMMs are also required to be members of the LSE.

The key obligation of GEMMs is to make two-way prices on demand in all gilts, thereby providing liquidity to the market. Some firms observe this requirement more closely than others! Certain gilts that the DMO has designated as rump stocks do not form part of this requirement. GEMMs also must participate in gilt auctions, the main method through which the DMO issues gilts, making competitive bids in all auction programmes. The third primary requirement of a GEMM is to “provide information to the DMO on market conditions, [its] positions and turnover” (DMO 1999). In return for carrying out its market-making obligations, a GEMM receives certain privileges exclusive to it, which are:

- the right to make competitive telephone bids at gilt auctions and tap issues;
- a reserved amount of stock at each auction, available at non-competitive bid prices (currently this is 1/2% of the issue for each GEMM, or 10% if an I-L gilt);
- access to the DMO's gilt dealing screens, through which the GEMM may trade or switch stocks;
- a trading relationship with the DMO whenever it wishes to buy or sell gilts for market management purposes;
- the facility to strip gilts;
- a quarterly consultation meeting with the DMO, which allows the GEMM to provide input on which type of stocks to auction in the next quarter, plus advice on other market issues;
- access to gilt inter-dealer broker (IDB) screens.

In 1998 the DMO set up a separate category of GEMMs known as index-linked GEMMs (IG GEMMs). A firm could opt for a registration for either or both category. The role of an IG GEMM is the same as that for a conventional GEMM, as applied to index-linked gilts. An IG GEMM has the same obligations as a GEMM with respect to I-L gilts, and an additional requirement that they must seek to maintain a minimum 3% market share of the I-L gilt market. Therefore an IG GEMM must participate actively in auctions for I-L stock. In addition to the privileges listed above, up until November 2001 IG GEMMs also had... gilt. This role of the DMO in the IG market was removed as the market matured. IG GEMMs also have the right to ask the DMO to bid for any I-L gilt. In September 2002, eight of the 16 GEMMs were also registered as IG GEMMs. No firm was registered solely as an IG GEMM.

### **3.4.1 *Gilt market broker functions***

There are, at the time of writing, four firms that provide an inter-dealer broker (IDB) service for GEMMs (Appendix 3.3). This is a facility for GEMMs to advertise, via the IDB's screens, anonymous live dealing prices for any gilt, together with the nominal value of the stock that they are prepared to deal in. Only GEMMs have access to IDB screens, which assist in the provision of market liquidity. IDBs are required to be members of the LSE and are recognised by the DMO. They are pure brokers and are prohibited from taking principal positions in any gilt or providing market intelligence outside their customer base.

A separate category of LSE broker is the broker/dealer. These are firms that act both for their own account or as agents for another party. Broker/dealers therefore trade with both market makers and client firms, and can deal with clients either as principal or agent. Broker/dealers may also act as wholesale broker/dealers to GEMMs.

### **3.4.2 *The role of the Bank of England***

Although the responsibility for UK government debt management has been transferred to the DMO, the BoE continues to maintain a link with the gilt market. The Bank is also involved in monitoring other sterling markets such as gilt futures and options, swaps, strips, gilt repo and domestic bonds. The Bank's *Quarterly Bulletin* for February 1999 listed its operational role in the gilt market as:

- calculating and publishing the coupons for index-linked gilts, after the publication of each month's inflation data and inflation index;



- setting and announcing the dividend for floating-rate gilts, which is calculated as a spread under three-month Libid each quarter;
- operating the BoE brokerage service, a means by which private investors can buy and sell gilts by post instead of via a stockbroker. This service was previously operated by National Savings, the government's savings bank for private retail customers. Private investors sometimes wish to deal in gilts via the post as usually commission charges are lower and it is a user-friendly service.

This is in addition to the normal daily money market operations, which keep the Bank closely connected to the gilt repo market. The BoE's dealers also carry out orders on behalf of its customers, primarily other central banks.

The BoE has a duty to "protect the interests of index-linked gilt investors" (DMO 1999). This is a responsibility to determine whether any future changes in the composition of the RPI index would be materially harmful to I-L gilt holders, and to effect a redemption of any issue, via HM Treasury, if it feels any change had been harmful.

The BoE used to operate the Central Gilts Office (CGO) settlement mechanism on behalf of CrestCo Limited; the two bodies have now merged. It also acts as the central registrar for gilts. The settlement process for gilts is reviewed separately.

### ***3.4.3 The role of the London Stock Exchange***

The gilt market is an OTC market where trading is conducted over the telephone. However all gilts are listed instruments on the LSE, and GEMMs and inter-dealer brokers are members of the LSE. A new gilt issue and further issues of an existing stock are always listed on the LSE, usually on the day the auction or the further issue is announced.

Members of the LSE must follow its conduct of business rules; in addition there are specific rules that apply to GEMMs. These include the requirement to report all gilt trades to the LSE, except gilt repo and stock loan trades. The LSE publishes market trading statistics that include the monthly turnover, by volume, of gilt transactions. It also publishes the Daily Official List, the list of closing prices for all securities listed on the London market.

## **3.5 Issuing gilts**

Auctions are the primary means of issuance of all gilts, both conventional and index-linked. They are generally for £2–£3 billion of stock on a competitive bid price basis. Auctions of index-linked gilts are for between £0.5 billion and £1.25 billion. The programme of auctions is occasionally supplemented in between auctions by sales of stock "on tap". This is an issue of a further tranche of stock of a current issue, usually in conditions of temporary excess demand in that stock or that part of the yield curve. That said, only one conventional stock has been tapped since 1996, a £400 million conventional tap in August 1999. The DMO has stated that tap issues of conventional gilts will only take place in exceptional circumstances.

After an auction the authorities generally refrain from issuing stocks of a similar type or maturity for a "reasonable" period. Such stock will only be issued if there is a clear demand. The 1996/97 remit for gilt issuance was accompanied by changes to the structure for gilt auctions. These changes were designed to encourage participation in auctions and to make the process more smooth. The average size of auctions was reduced and a monthly schedule put in place.

Periodic dual auctions were also introduced. Dual auctions allow the issue of two stocks of different maturity in the same month, which moderates the supply of any one maturity and also appeals to a wider range of investors. Market makers (GEMMs) were allowed to telephone bids in up to five minutes before the close of bidding for the auction, which allowed them to accommodate more client demand into their bids. Instituting a pre-announced auction schedule at the start of the fiscal year further assists market transparency and predictability in gilt auctions, which reduced market uncertainty. In theory a reduction in uncertainty should result in lower yields over the long term, which reduce government borrowing costs.

The DMO has a slightly different auction procedure for I-L gilts. Unlike conventional gilts, which are issued through a multiple price auction, I-L gilts are auctioned on a uniform price basis. This reflects the higher risks associated with bidding for I-L stock. In an auction for a conventional gilt, a market maker will be able to use the yields of similar maturity stock currently trading in the market to assist in their bid; in addition a long position in the stock can be hedged using exchange-traded gilt futures contracts. There is also a very liquid secondary market in conventional gilts. For these reasons a market maker will be less concerned about placing a bid in an auction without knowing at what level other GEMMs are bidding for the stock. In an I-L gilt auction there is a less liquid secondary market and it is less straightforward to hedge an I-L gilt position. There are also fewer I-L issues in existence, indeed there may not be another stock anywhere near the maturity spectrum of the gilt being auctioned. The use of a uniform price auction reduces the uncertainty for market makers and encourages them to participate in the auction.

### **3.5.1 Auction procedure**

As part of its government financing role, HM Treasury issues an auction calendar just before the start of the new financial year in April. The DMO provides further details on each gilt auction at the start of each quarter in the financial year, when it also confirms the auction dates for the quarter and the maturity band that each auction will cover. For example, the quarterly announcement might state that the auction for the next month will see a gilt issued of between four and six years' maturity. Announcements are made via Reuters, Telerate and Bloomberg news screens. Eight days before the auction date the DMO announces the nominal size and the coupon of the stock being auctioned. If it is a further issue of an existing stock, the coupon obviously is already known. After this announcement, the stock is listed on the LSE and market makers engage in "when issued" trading (also known as the *grey market*). When issued trading is buying and selling of stock to the forward settlement date, which is the business day after the auction date. As in the Eurobond market, when issued trading allows market makers to gauge demand for the stock amongst institutional investors and also helps in setting the price on the auction day.

#### ***Conventional gilts***

In conventional gilt auctions bidding is open to all parties.<sup>6</sup> Institutional investors will usually bid via a GEMM. Only GEMMs can bid by telephone directly to the DMO.<sup>7</sup> Other

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<sup>6</sup> Including private individuals.

<sup>7</sup> When telephoning one's bid, it is important to quote the correct "big figure" for the stock! Oops!

bidders must complete an application form. Forms are made available in the national press, usually the *Financial Times*. Bidding can be competitive or non-competitive. In a competitive bid, participants bid for one amount at one price, for a minimum nominal value of £500,000. If a bid is successful the bidder will be allotted stock at the price they put in. There is no minimum price. Telephone bidding must be placed by 10.30am on the morning of the auction and in multiples of £1 million nominal. Bidding is closed at 10.30am. In a non-competitive bid, GEMMs can bid for up to 1/2% of the nominal value of the issue size, while others can bid for up to a maximum of £500,000 nominal, with a minimum bid of £1,000. Non-competitive bids are allotted in full at the weighted-average of the successful competitive bid price. In both cases, non-GEMMs must submit an application form either to the BoE's registrar department or to the DMO, in both cases to arrive no later than 10.30am on the morning of the auction.

The results of the auction are usually announced by the DMO by 11.10am. The results include the highest, lowest and average accepted bid prices, the gross redemption yields for these prices, and the value of non-competitive bids for both GEMMs and non-GEMMs. The DMO also publishes important information on auction performance, which is used by the market to judge how well the auction has been received. This includes the difference between the highest accepted yield and the average yield of all accepted bids, known as the *tail*, and the ratio of bids received to the nominal value of the stock being auctioned, which is known as the *cover*. A well-received auction will have a small tail and will be covered many times, suggesting high demand for the stock. A cover of less than 1.5-times is viewed unfavourably in the market and the price of the stock usually falls on receipt of this news. A cover over 2-times is well received. On rare occasions the cover will be less than one, which is bad news for the sterling bond market as a whole. A delay in the announcement of the auction result is sometimes taken to be as a result of poor demand for the stock. The DMO reserves the right not to allot the stock on offer, and it is expected that this right might be exercised if the auction was covered at a very low price, considerably discounted to par. The DMO also has the right to allot stock to bidders at its discretion. This right is retained to prevent market distortions from developing, for example if one bidder managed to buy a large proportion of the entire issue. Generally the DMO seeks to ensure that no one market maker receives more than 25% of the issue being auctioned for its own book.

### ***Index-linked gilts***

Auction bids for I-L gilts are also competitive and non-competitive. Only IG GEMMs may make competitive bids, for a minimum of £1 million nominal and in multiples of £1 million. For I-L gilts there is a uniform price format, which means that all successful bidders receive stock at the same price. A bid above the successful price will be allotted in full. Non-competitive bids must be for a minimum of £100,000, and will be allotted in full at the successful bid price (also known as the "strike" price). IG GEMMs are reserved up to 10% of the issue in the non-competitive bid facility. Non-IG GEMMs must complete and submit an application form in the same way as for conventional gilt auctions.

The DMO reserves the right not to allot stock, and to allot stock to bidders at its discretion. The maximum holding of one issue that an IG GEMM can expect to receive for its own book is 40% of the issue size.

### 3.5.2 *Tap issues*

Prior to the adoption of the competitive bid mechanism, taps were the main method of issuing gilts. A tap is a tender for an amount of stock at a minimum price, announced on the morning of the tender. Bids must be received no more than 30 minutes later. An auction procedure has been used for some time now for conventional gilts, but was only adopted in November 1998 for I-L gilts. As such taps are now used only for “market management” purposes, rather than as a form of issue, for all gilts. Market management covers specific one-off conditions such as an excess demand for one stock, or a shortage of stock in the market leading to trading illiquidity. In these circumstances the DMO may “tap” an issue to relieve this condition, by issuing a small amount of the stock into the market. The DMO has stated that taps will not be conducted on stocks a minimum of three weeks either side of an auction for that stock. Tap issues are of small size, usually only £100 million and never more than £400 million. The tap issue result is announced as soon as possible.

### 3.5.3 *Conversions*

In the new reformed environment of the gilt market, the emphasis is on having a large, liquid supply of *benchmark issues* in existence. The BoE used conversion offers to switch holdings of illiquid gilts into more liquid benchmark stocks. The DMO has instituted a formal conversion programme. Conversion offers are made to bondholders to enable them to exchange (convert) their gilts into another gilt. The new gilt is usually the benchmark for that maturity. The aim behind conversion offers is to build up the issue size of a benchmark gilt more quickly than would be achieved by auctions alone, which are a function of the government’s borrowing requirement. A period of low issuance due to healthy government finances would slow down the process of building up a liquid benchmark. By the same token, conversions also help to increase the size and proportion of strippable gilts more quickly. Conversions also, in the words of the DMO, concentrate liquidity across the yield curve by reducing the number of illiquid issues and converting them into benchmark issues. Illiquid gilts are usually high coupon issues with relatively small issues sizes. In the past for example, double-dated gilts have been converted into benchmark gilts. Gilts that may be converted are usually medium and long-dated bonds with less than £5.5 billion nominal outstanding. The current distribution of a gilt is also taken into consideration: issues that are held across a wide range of investors, particularly private retail investors, are less likely to be offered for conversion as the offer will probably not be widely taken up.

The aim of HM Treasury and the DMO is to have liquid benchmark gilts at the 5, 10 and 30-year maturity end of the yield curve. Conversion assists this process. The DMO uses the forward yield curve in setting the terms of the conversion offer. The aim of the process is to make an offer to bondholders of the “source” stock<sup>8</sup> such that a large proportion of the stock is converted at a value fair to both the bondholder and the government. The conversion ratio is calculated using the dirty price of both source and “destination” gilts. Both bond cash flows are discounted to the conversion date using the forward yield curve derived on the date of the conversion offer announcement. This approach also takes into account the “pull-to-par” of both stocks; the running cost of funding a position in the source stock up to

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<sup>8</sup> This is the stock being converted out of.

the conversion date is not taken into account. Conversion terms are announced three weeks before the conversion date.

On announcement of the conversion terms, the DMO holds open the fixed terms for the three week offer period, in the form of a fixed price ratio of the two stocks. If the terms move in bondholders' favour they can convert, whereas if terms become unfavourable they may choose not to convert. It is not compulsory to take up a conversion offer. Holders of the source stock may choose to retain it and subsequently trade it, or hold it to maturity. However the source stock will become less liquid and less widely held after the conversion, more so if the offer is taken up in large quantities. If the remaining amount of the source stock is so small that it is no longer possible to maintain a liquid market in it, thereby turning it into a rump stock, GEMMs are no longer required to make a two-way price in it. Even if the stock does not end up as a rump issue, the bid-offer spread for it may widen. However these are not issues if the investor is seeking to hold the bond to maturity. The DMO will announce if a stock acquires rump status; it also undertakes to bid for such stocks at the request of a market maker, as assistance towards the maintenance of an orderly market.

In a conversion in October 1999, the DMO offered to convert holdings of 8% 2003 gilts into the new benchmark five-year stock, the 5% 2004. Approximately £1 billion of the older gilt was converted into £1.1 billion of the new benchmark bond. The conversion was very attractive to holders of the source bond and was oversubscribed, being covered more than five times. The results of the offer are summarised in Table 3.3.

## 3.6 The DMO and secondary market trading

### 3.6.1 *Secondary market operations*

As part of its role in maintaining an orderly and efficient market the DMO conducts business in the secondary markets in line with specific requirements and demand. This business generally involves trading with GEMMs in response to particular situations, including the following:

- bidding for rump stock;
- switches of stock;
- in special situations, bidding for conventional stock;
- intervening to make stock available for repo in circumstances where a false market has resulted in specific issues being unavailable for borrowing or purchase;
- sale of stock from official portfolios.

These situations are now considered in this section.

#### *Bidding for rump stock*

The DMO acts as a buyer of last resort for gilts that have been designated rump stocks, for which GEMMs are not required to quote two-way prices. Although the DMO only deals direct with GEMMs, institutions or private individuals can ask for a bid price via a broker, who will deal with the GEMM.

#### *Switches of stock*

GEMMs may request switches out of or into stocks that are held on official portfolios, which the DMO will carry out amongst stocks of the same type. The terms of any switch are set by the DMO.

### *Bidding for conventional stock*

In exceptional circumstances the DMO will announce that it will accept offers of a specific stock, acceptance of which is at the DMO's discretion.

### *Supplying stock for use in repo*

In certain circumstances a specific issue will go "tight" in the repo market, meaning that it is difficult to borrow the stock for delivery into short sales. This is typically reflected in the stock going *special* in the repo market.<sup>9</sup> On rare occasions the stock may become undeliverable, leading to failed transactions and also failure to deliver into the equivalent gilt futures contract. When this happens the DMO may make the stock available for borrowing, out of official portfolios, or issue a small amount of the stock into the market.

### *Sale of stock from official portfolios*

The DMO will acquire amounts of stock as a result of its secondary market operations, and these holdings may be made available for re-sale into the market. Although it does not actively offer stock to the market, when holdings are made available from its portfolios the DMO will announce via its news screen the stock on offer, and the size available; this is known as the DMO's "shop window". No offer price is indicated, but bids must be at the market level or above; acceptance is at the DMO's discretion. If more than £50 million of one issue is on offer a mini-tender is held, announced via the DMO's news screens.

## **3.6.2 Closing reference prices**

After the close of business each day the DMO publishes reference prices and the equivalent gross redemption yields for each gilt on its news screens. The final reference price is based on closing two-way prices supplied by each GEMM at the end of the day. The prices, previously referred to as "CGO reference prices" but now following the merger of the CGO with CREST, called DMO or gilt reference prices, are frequently used in the calculation of settlement proceeds in repo and stock loan transactions. The derivation of the reference price is described in Appendix 3.4.

## **3.7 Settlement**

### **3.7.1 Crest**

Originally the settlement of gilts was undertaken by the Central Gilts Office (CGO) of the Bank of England. This was the computerised book-entry settlement system for gilts. It was first introduced in 1986. The system was upgraded in 1995 to allow for the introduction of new gilt products, namely gilt repo and strips. CGO provided facilities for gilt investors to hold stock in *dematerialised* form, and transfer stock electronically. Transfers were processed by an assured payment system based on the principle of *delivery versus payment* (DVP). Thus the CGO provided a secure system for the electronic holding and transfer of stocks between members without the need for transfer forms and bond certificates. The service was originally established by the BoE and the LSE to facilitate the settlement of specified securities, essentially gilts and certain sterling bonds such as bulldogs for which the BoE acts as registrar, and was upgraded by the BoE in 1997. This upgrade enhanced the CGO facility to settle gilt repo trading activity, which commenced in January 1996, and to

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<sup>9</sup> A *special* repo rate is below the general repo rate.

cater for the introduction of the gilt strips facility in December 1997. It also provided a vehicle for the development of real-time DVP through links to the Real Time Gross Settlement System (RTGS) for wholesale payments, which was introduced in 1996.

In May 1999 responsibility for the CGO service was transferred to CRESTCo Limited, the company that operates the Crest settlement system for London market equities. The gilt settlement service is now operated within Crest, with the merger process completed in July 2000.

The basic concept of the CGO within Crest remains the same, that is the provision of secure settlement for gilt-edged securities through an efficient and reliable system of electronic book-entry transfers in real time against an assured payment. The CGO is a real-time, communication-based system. Settlement on the specified business day (T + 1 for normal gilt trades) is dependent on the matching by CGO of correctly input and authenticated instructions by both of the parties and the successful completion of pre-settlement checks on the parties' stock account balances and credit headroom.

The CGO provides facilities for:

- settlement of stock and cash transfers;
- overnight transfer of collateral, known as Delivery by Value (DBV), to allow CGO members to pass stock against a secured overnight loan;
- automatic reporting of all transactions to the London Stock Exchange;
- matching of instructions between counterparties;
- the movement of stock free of payment;
- processing of stock lending and repo transactions.

In addition the following facilities were added at the upgrade:

- the stripping and reconstitution of gilts, at the request of GEMMs, the DMO and the BoE;
- forward-dated input, useful for the input of gilt repo;
- greater control by settlement banks over the credit risks run on their customers (by means of a debit-capped payment mechanism);
- a flexible membership structure (allowing the names of "sponsored" as well as "direct" members to appear on the register);
- multiple account designations.

All GEMMs as well as most banks and large building societies are members of Crest. Certain institutional investors and brokers are also members. The membership stood at around 300 in 1999, including nominee companies. Over 90% of the total value of gilts was held in dematerialised form in CGO in September 1999. Firms who trade less frequently in gilts often settle through an agent bank. This indirect participation in Crest is usually done via a nominee company, usually a current bank member, or via sponsored membership. In the case of sponsored membership a company opens a Crest account in its name but the sponsor is responsible for conducting the firm's gilt settlement activity.

Part of the reforms in the gilt market through 1998 included a facility for overseas investors to hold gilts in what was then CGO, via either the Euroclear or Clearstream clearing systems. This became possible after both Euroclear and Clearstream opened accounts at CGO.

### 3.7.2 *Delivery by value (DBV)*

Delivery by value is a mechanism whereby a CGO member may borrow money from or lend money to another CGO member against overnight gilt collateral. The CGO system automatically selects and delivers securities to a specified aggregate value on the basis of the previous night's CGO Reference Prices; equivalent securities are returned the following business day. The DBV functionality allows the giver and taker of collateral to specify the classes of security to be included within the DBV. The options are: all classes of security held within CGO, including strips and bulldogs; coupon bearing gilts and bulldogs; coupon bearing gilts and strips; only coupon bearing gilts.

DBV repo is a repo transaction in which the delivery of the securities is by the DBV mechanism in CGO; a series of DBV repos may be constructed to form an "open" or "term" DBV repo. The DBV functionality allows repo interest to be automatically calculated and paid.

### 3.7.3 *Merger of CREST and Euroclear*

During 2002 CREST merged with the Euroclear company. The merger was announced by the respective Boards of the two companies in July 2002, for effect from September 2002. From this time CRESTCo became a wholly-owned subsidiary of Euroclear plc. CRESTCo shareholders received a 19% stake in the merged body. In 2003 CRESTCo is expected to become part of Euroclear Bank SA/NV.

The merged group provides settlement services for bonds across a number of markets, including Belgian, Dutch, French and UK securities, as well as international securities issued into the Euromarkets. The merger means that Europe-wide settlement and clearing systems, including those operated by Euroclear and CREST, have been integrated into one operating entity. The clients of the group may choose the jurisdiction under which they clear and hold securities. The administrative burden is reduced for investors who hold bonds across more than one jurisdiction, as they now have one Euroclear account for all Euromarket securities and certain government bonds as noted above.

Table 3.1 shows settlements statistics for the two bodies at the time of the merger.

	CRESTCo	Euroclear
Value of securities	€96,400 bn	€130,000 bn
	£59,900 bn	\$91,000 bn
Number of pre-netted transactions settled	74 million	161 million
Number of netted transactions settled	74 million	47 million
Securities held in custody	€2,900 bn	€7,900 bn
	£1,800 bn	£4,800 bn
Number of eligible securities	16,000	208,000
Number of domestic market links	3	32
Number of settlement currencies	3	32

**Table 3.1:** Euroclear/CRESTCo settlement details as at December 2001. Source: Bank of England *Quarterly Bulletin*, Winter 2002, Vol 42, No 4.



## 3.8 HM Treasury and the remit of the DMO

In May 1997 the BoE was granted independent powers for the setting of interest rates. At the same time the government began the process of transferring the Bank's responsibility for debt and cash management to the newly-created DMO, which process was completed in April 1998. From that date the responsibility for gilt issuance was taken over by the DMO. The role of the DMO covers all official operational decision-making in the gilt market. From the last quarter of 1999 the DMO also assumed responsibility for cash management for HM Government.

The DMO is an executive agency of HM Treasury. Its remit appears in the *Debt and Reserves Management Report*. The DMO's main objectives are to meet the annual remit for the sale of gilts, with an emphasis on minimising the cost to HM Treasury; and to promote a liquid market for gilts and gilt trading. To facilitate this the DMO attempts to conduct its operations in as transparent a way as possible, again with a view to keeping costs to the Treasury as low as possible. The DMO has also set itself further objectives that include responding to the demand for new products and providing quality customer service. As part of its remit for 1998/99 the DMO published an auction calendar, and increased the proportion of index-linked gilts that are issued as part of the total funding requirement. Although the DMO is part of HM Treasury, it operates as a separate agency and at arm's length from the government. Policy though is ultimately set by the Chancellor.

In December 1998 the DMO published its framework for the future of UK government cash management, for which it assumed responsibility in 1999. The main objective for the DMO is to cover Exchequer cash flows that are anticipated from its forecasts; this will be accomplished through a structured Treasury Bill programme and also through daily money market operations. The BoE will conduct its daily money market operations in the normal manner, which involves bill and repo tenders at 09.45 and 14.30 each day. The DMO has stated that it will work to avoid clashes with the Bank's operations.

### 3.8.1 Structure of debt management

A review of debt management policy<sup>10</sup> in 1995 resulted in significant reform of the gilt market and its structure. The most visible result of these reforms was the introduction of the gilt repo and strips markets. Other changes were made with a view to enhance the transparency and liquidity of the market, as well as to increase the attraction of the market for overseas investors. There was also a new debt management ethos that included the following:

- an emphasis on building up large benchmark issues of gilts along the 5, 10 and 30-year points on the yield curve. This has resulted in fewer gilt issues but more of a larger nominal size. For example the number of conventional issues outstanding has fallen from 96 in 1992 to 68 in March 1999 (of these, 20 were rump issues that trade infrequently). There are also more large size issues; in March 1999 there were 22 gilts with over £5 billion nominal outstanding in issue, whereas in 1992 there were only five such

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<sup>10</sup> *Report of the Debt Management Review*, July 1995, published jointly by HM Treasury and the Bank of England.

gilts. In 1999 one gilt issue, the 8% Treasury 2021, was the second largest bond issue in the world, with £16.5 billion nominal outstanding;<sup>11</sup>

- gilt issuance is in accordance with an auction calendar that has been released at the start of the fiscal year;
- the government's borrowing forecast is announced at the start of the fiscal year, in a Debt Management Report (DMR) issued by HM Treasury. The DMR includes a forecast of the amount, type and maturity of gilts that are to be issued in the year. GEMMs and institutional investors are involved in a consultation process with the DMO on the formulation of these plans.

The new revised debt management structure also states that the DMO will consult with market participants to ensure the continued liquidity and transparency of the market.

### 3.9 Exchange-traded gilt derivatives

The gilt market forms the cornerstone of the sterling asset markets. Therefore the exchange-traded market in gilt derivatives is an important feature of the debt capital markets as a whole. In terms of derivatives both the LIFFE and MATIF futures exchanges trade standard futures and option contracts on gilts. This section presents an overview of the main exchange-traded gilt contract, the LIFFE Long Gilt futures contract; we will look at it again in terms of the gilt basis.

A futures contract is a financial instrument that is a legally binding obligation to make or take delivery of an underlying specified asset at a fixed date in the future, at a price agreed at the time the contract is entered into. The asset can be a tangible one such as wheat or oil or a non-tangible one such as an equity index. Futures contracts written on non-tangible assets such as financial instruments are known as *financial futures*. Both commodity and financial futures are used for hedging and speculative purposes.

#### 3.9.1 LIFFE long gilt contract

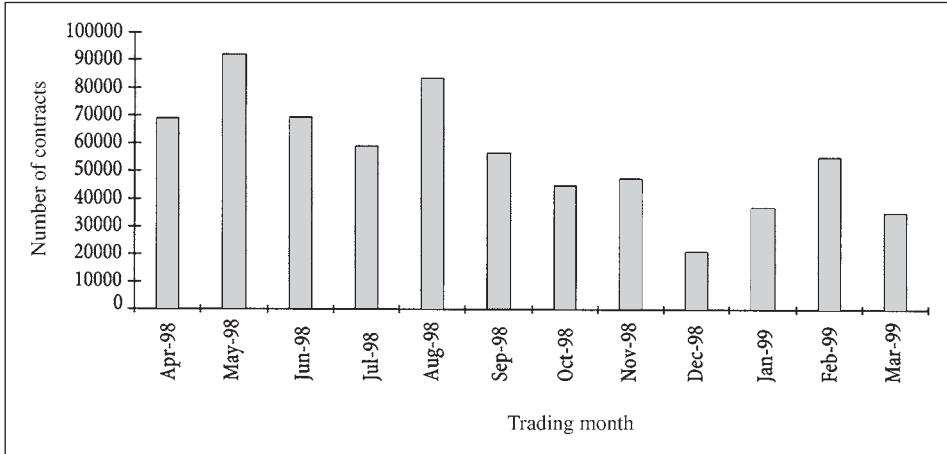
LIFFE's long gilt futures contract was the first government bond futures contract listed in Europe, in 1982. In 1998 the contract's specifications were changed to reflect changes in the gilt cash market structure, and one *lot* of the contract now represents £100,000 nominal of a gilt of a *notional* 7% coupon and maturing in from  $8\frac{3}{4}$  to 13 years. The price quoted is, like cash gilts, in decimal units (£0.01) and the bid-offer spread is usually £0.01. During 1998 the average daily trading volume in the long gilt was 64,000 lots<sup>12</sup> and the number of *open interest* contracts ran at an average level of 164,000 during the year. Open interest represents the number of contracts that are run overnight and not closed out before the end of the trading day; the level of open interest is one reflection of the size of the hedging demand for gilts and other sterling bonds.

In the early 1990s a medium-gilt future was also traded on LIFFE, but was later discontinued due to low trading volumes. In January 1998 the contract was re-launched, with the

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<sup>11</sup> The world's largest issue in 1999 was a US Treasury bond, coincidentally also an 8% 2021, with \$32.8 billion nominal outstanding.

<sup>12</sup> Source: LIFFE.



**Figure 3.5:** LIFFE long gilt future average daily trading volume. (Source: LIFFE).

same terms as the long gilt future but with the underlying gilt specified as one of between 4–7 years' maturity. The delivery cycles of both contracts follow market convention for exchange-traded contracts, with expiry dates in March, June, September and December each year.

There are a range of users of gilt futures contracts. These include:

- GEMMs and market makers of sterling denominated bonds;
- market-makers in sterling interest rate swaps;
- institutional investors in the gilt market including fund managers, pension funds and life companies;
- issuers of sterling bonds including Eurobonds and bulldogs;
- speculators and arbitrageurs such as securities houses and hedge funds.

The market participants noted above use gilt futures for a range of purposes. A GEMM will be concerned with hedging its cash gilt book, institutional investors will also be concerned with hedging as well as investing future cash flows, portfolio duration adjustment, portfolio insurance and income enhancement.<sup>13</sup> Issuers of sterling bonds use futures to hedge their underwriting positions. Finally, traders such as speculators and arbitrageurs will trade futures as part of a directional play on the market, for yield curve trades and as part of volatility trading.

The delivery process for a futures contract is connected to its pricing, as this provides the link to (and convergence with) the cash market. However only a small percentage of futures contracts traded are actually taken to delivery. It is the party that is the seller of the contract (and who runs the position into the delivery month) that may choose to deliver a gilt from a list of deliverable gilts that meet the contract's specifications. Therefore the buyer of a contract (again, who runs the position into the delivery month) will anticipate receiving the particular gilt that will create the maximum profit or minimum loss for the delivering seller when assessing the fair price of the contract. This bond

<sup>13</sup> These last two functions actually employ options on gilt futures.

is known as the *cheapest-to-deliver* (CTD) gilt. To identify the CTD gilt, and therefore the fair price of the futures contract, it is necessary to look at the potential profit or loss from what is known as a *cash-and-carry* arbitrage. This is a position consisting of a long position in the underlying bond and an equivalent short position in the futures contract. Both positions must be put on simultaneously. The cash-and-carry arbitrage profit/loss calculation is given by:

Cash inflow less cash outflow = short futures – long underlying:

(futures price  $\times$  price factor + accrued interest at delivery + coupon income)

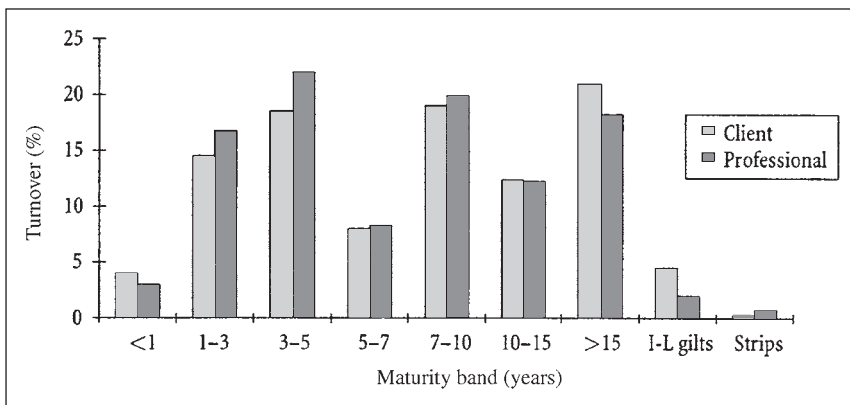
(less long gilt clean price + accrued interest at purchase + financing cost).

To consider our arbitrage trade then, since an arbitrage gain can be made if the price of the futures contract and the corresponding price of the CTD gilt are out of line, the market forces the price of the futures contract to closely track the price of the underlying gilt that is the CTD gilt at the time. The close relationship between the long gilt futures price and the price of the CTD gilt means that the future contract provides a flexible hedging mechanism for both gilts and other long-dated sterling bonds. The same consideration applies for the medium gilt futures contract and medium-dated gilts and sterling bonds.

A detailed look at the gilt future basis is given in Chapters 8 and 9.

### 3.9.2 LIFFE gilt options

The popularity and liquidity of the gilt futures contract led to the listing of gilt options on LIFFE in March 1986. Average daily volume in this contract was more than 12,000 lots during 1998. The contract is an option on the futures contract and not a cash gilt. The options are “American” style options, which means they can be exercised by the long at any time between trade date and expiry date. They are agreements under which the buyer acquires the right (but not the obligation) to take (*call*) or make (*put*) delivery of the underlying futures contract, at the price agreed at the time of dealing. On LIFFE “serial expiry months” are available for its exchange-traded options; serial options are expiry



**Figure 3.6:** Percentage of GEMM market turnover by maturity band (September 1999).  
Source: BoE.

months other than the traditional quarterly months of March, June, September and December. Gilt option expiry months are listed such that the two nearest serial months and the two nearest quarterly months are always available for trading.

Traditionally gilt futures and options have been traded by open-outcry in designated pits on the floor of the LIFFE exchange building. In April 1999 the exchange launched an electronic dealing platform known as Connect for Futures. The long gilt contract was the first to be traded on it. The system is a screen-based dealing platform that also enables traders to observe the depth of the market, as orders above and below the current bid and offer level are listed on the screen. Although floor trading in individual pits was retained, LIFFE announced in October 1999 that all futures and options trading was to move to an electronic screen-based platform by the end of the year, and trading had moved off the floor by the end of November 1999.

### 3.9.3 *Gilt repo market*

The term repo comes from the expression “sale and repurchase” agreement. Repo is a short-term money market instrument and is typically a loan secured with bonds as collateral. Although repo is a well-established instrument and has existed in the US Treasury market from 1918, it was introduced only recently in the gilt market, in January 1996. Prior to this there was no facility to borrow gilts via a repo transaction. Gilt-edged market makers were able to borrow stock from designated Stock Exchange Money Brokers (SEMBs) in order to deliver into a short sale. The SEMBs obtained the stock from institutional investors with large holdings of gilts, and stock was lent to GEMMs in return for collateral, usually posted as other gilts or cash. The introduction of an open market in gilt repo enabled any market participant to borrow gilts and also to fund gilt positions at a lower rate (the *repo rate*) than the interbank lending rate. This contributed to improved cash market liquidity. The market quickly grew to over £50 billion of repo outstanding, developing alongside the existing unsecured sterling money market. Market size stood at over £105 billion by the end of March 1999.<sup>14</sup>

The BoE is involved in the repo market as part of its daily operations in the sterling money markets. From the first quarter of 2000 the DMO also used gilt repo as part of its cash management operations on behalf of the government, which are designed to smooth the net daily cash flows between central government and the private sector.

Gilt repo is reviewed in detail in Chapter 6.

## 3.10 The Minimum Funding Requirement

In May 1997, shortly after a general election that brought the Labour party to power for the first time since 1979, the responsibility for the conduct of monetary policy was transferred to the BoE. Shortly after that the gilt yield curve inverted, an occurrence explained by bond analysts as reflecting the new 2.5% long-term inflation target set for the BoE and the prospect of eventual sterling entry into the European Union’s euro currency. The curve

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<sup>14</sup> Source: DMO.

remained inverted, changing slightly in July 1999 to being positive sloping out to seven years before inverting for the remaining term to maturity.<sup>15</sup>

The continued inverted nature of the curve, especially the historically very low yields at the very long end of the curve, reflect high demand for long-dated gilts and a relative lack of supply at this end of the curve. The high demand has been explained partly as a result of the Minimum Funding Requirement (MFR) and its effect on pension funds' investment. In this section we review the MFR and the impact of the inverted yield curve on future funding.

### **3.10.1 Definition**

The MFR was the term given to government reform of the regulation of occupational pension schemes.<sup>16</sup> The reforms introduced an MFR as part of pensions reform, to be introduced in a phased scheme from April 1997 through to 2002. The MFR is not a requirement for pension funds to hold gilts but rather a notice on the discount rate that a pension fund should use when determining the value of its liabilities with respect to different members of the fund scheme. The liabilities for pensioners must be calculated using a discount rate relating to the current yield on long-dated gilts, either conventional or I-L gilts as appropriate to the fund. Long-dated gilts are taken to be those of greater than 15 years to maturity. Subsequent analysis by some market commentators has stated that this has increased the importance of long-dated gilts to pension funds, and implied that holdings of these instruments have increased as a direct result.

### **3.10.2 Impact on the gilt market**

Although the MFR will influence a pension fund's view on long-dated gilt yields, the requirement itself is not an instruction to hold the instruments themselves. There are several factors that have contrived to depress long-dated gilt yields however, which we can consider here.

In the first instance the reduction in government borrowing has resulted in a supply shortage of gilts generally, not just at the long end of the curve. From a net gilt sales requirement of over £35 billion in 1993/1994, the figure fell to a surplus of nearly £10 billion in 1998/1999 and a projected net requirement of less than £5 billion for the year 1999/2000. The decreasing supply has contributed to low long-dated gilt yields. For pension funds a further issue from the year 2000 was that £14 billion of long gilts were re-classified as "mediums" because they mature in 2015.

The historically low yields on gilts also reflect the economic performance of the UK economy and the benign future inflation expectations in place. This has more of an impact than any perceived shortage of stock at the long end. In fact the UK gilt stock has a higher average maturity than most developed country bond markets, and this exposes the government to relatively higher interest rate risk. The demand for gilts stretches across the maturity spectrum and only one class of investor (the pension funds) has a comparatively high interest at the very long-end. Other institutional investors concentrate on the short

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<sup>15</sup> This positively-sloping curve was short-lived; the shape reverted to negatively-sloping from the 2-year maturity shortly after. It eventually reverted to positively sloping and was a conventional shape as at December 2002.

<sup>16</sup> This formed part of the Pensions Act (1995).

(banks, building societies) and medium (life companies) end of the yield curve. The authorities do not believe the MFR itself to be solely behind the shape of the yield curve from 1997 onwards, which can be explained largely by the historically low level of supply, mature pension fund requirement for long-dated bonds, and historically low inflation expectations. Nevertheless, they instituted a review of the MFR, known as the Myners Report, which was delivered in November 2000. It recommended greater holding by institutional investors of highly-rated corporate bonds, which would relieve the demand at the long end of the gilt yield curve. It also recommended that the MFR should be abolished, and this decision has been taken in principle by the Government.

### 3.11 Developments in electronic trading

The DMO issued a consultation paper in January 2000 on its relationship with the GEMMs, which sought views on the likely impact on this relationship as a result of changes in the trading environment, once electronic trading platforms were introduced into the gilt market. The consultation period ran during the first quarter of 2000. Previously GEMMs carried out their market-making obligations via the telephone. The introduction of electronic trading platforms in bond markets around the world is an indicator that the gilt market will also switch to an electronic platform for secondary market trading in due course. A number of new electronic brokerages are already, or are planning to begin, operating in the euroland government bond markets, including the systems introduced during 1999 by the London Clearing House. Although sterling bonds were not traded on these systems in 1999, it was planned to introduce them as soon as possible. When this occurs there will be electronic matching and execution of trades. It is realistic to expect their introduction in gilts over the short term, and in response to this the DMO invited comment on whether its existing relationship with the GEMMs, and via them, its contact with the secondary market in gilts, remained suitable. In effect the DMO may have been concerned that secondary market obligations may not have been carried out as effectively over an electronic system, however the likely impact will probably be similar to the equity market, where liquid stocks are highly transparent to investors but illiquid ones are still difficult to trade in. It remains to be seen if an electronic trading platform would make dealing at the long end of the curve, which became slightly less liquid to deal in as demand outstripped supply during 1998 and 1999, any more transparent.

### 3.12 Market developments in 2001–2002

In this section we present statistics and latest gilt market developments during 2001 and 2002. Statistical data is sourced from the DMO, and reproduced with permission.

#### 3.12.1 *Gilt auctions*

During 2000/01 there were seven outright gilt auctions, including a new ultra-long gilt, the 4¼% Treasury 2032, in May 2000. The results are shown in Table 3.2.

The programme of switch auctions was continued. During 2000–01 there were three auctions out of 8% Treasury stock 2015 into the new ultra-long benchmark gilt, the 4¼% 2032. This resulted in the nominal outstanding of the older bond being reduced to £7.3 billion by December 2000, while increasing the issue size of the newer bond by £6.8 billion. The total issue size of the long-dated gilt was over £13 billion by the end of 2001.

Date	Stock	Nominal £m	Cover	Average accepted price (AAP)	Yield at AAP %
3 May 2000	2½% I-L 2020	375	2.30	£219.00	1.92
24 May 2000	4¼% 2032	2,500	1.63	£96.21	4.47
26 July 2000	2½% I-L 2013	425	1.94	£195.46	2.18
25 October 2000	4⅛% I-L 2030	450	2.07	£189.00	1.87
21 November 2000	4¼% 2032	2,250	2.21	£97.27	4.41
24 January 2001	2½% I-L 2016	450	3.16	£218.75	2.08
28 March 2001	4¼% 2032	2,000	1.82	£96.82	4.44

**Table 3.2:** Results of seven outright gilt auctions during 2000/01.

The DMO also undertook a programme of reverse auctions, to buy stock back from the market. This had last occurred during 1988–89 and 1989–90, when the BoE had bought back stock as a result of the government running budget surpluses. Paradoxically, the latest buy-backs were carried out to increase the financing requirement, to allow for more primary market issuance of long-dated gilts, which were in strong demand in the market. The stocks selected to be bought back were short or medium-dated gilts maturing during 2003–08, which had over £1 billion in issue and which were non-strippable. During 2000–01 the DMO managed six reverse auctions, which resulted in a total of £4.1 billion of stock being bought back. Further buy-backs can be expected, with short-dated and rump stocks also being considered for reverse auctioning.

At a reverse auction, the GEMMs will make an offer for stock that comprises:

- name of the stock;
- the amount of stock being offered;
- the offer clean price of the stock.

Each offer price is converted into a yield using the DMO price/yield convention; from this is subtracted a fitted yield for that stock, which is taken from the DMO yield curve. This gives a “yield residual” for each offer, with offers ranked in descending order of residual. In each reverse auction, the DMO purchased stock that was cheap to the theoretical yield curve. Figure 3.7 shows the breakdown of stocks purchased during the buy-back programme. This shows that the most popular stock for re-purchase was the 8½% Treasury 2007, indicating that this gilt was the cheapest to the curve in its maturity bracket.

### 3.12.2 Gilt market turnover

Turnover in the gilt market increased year-on-year during 2001. For instance, average daily turnover reported by the GEMMs increased by 7% from £5.7 billion to £6.1 billion, as shown in Figure 3.8. The DMO noted in its 2001 *Gilt Review* however that measured by “turnover ratio”, the increase in turnover was in the order of 12%. This measure is equal to the aggregate turnover relative to the market value of the portfolio at the beginning of the relevant financial year.

Weekly turnover data is reported in the DMO’s quarterly review of the gilt market. Average weekly turnover was £34 billion during the second half of 2001, which marked an increase of 35% compared to the same period in the previous year.



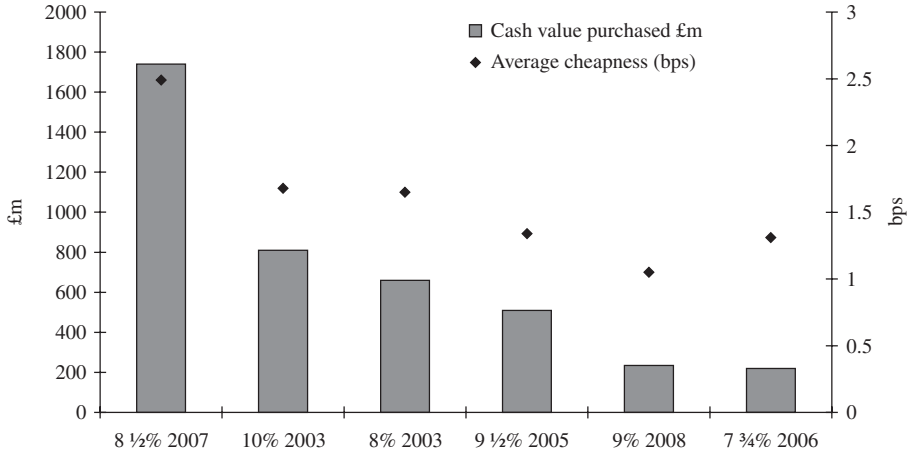


Figure 3.7: Buy-back stocks.

Type	Source gilt 9 1/2% 2004	Destination gilt 5% 2004
Nominal in issue before offer	£3,412 million	£2,500 million
Acceptances received	£3,105 million (91%)	-
New stock created	-	£3,789 million
Nominal in issue after offer	£307 million	£6,289 million

Table 3.3: 9 1/2% 2004 into 5% 2004 conversion offer, July 1999.

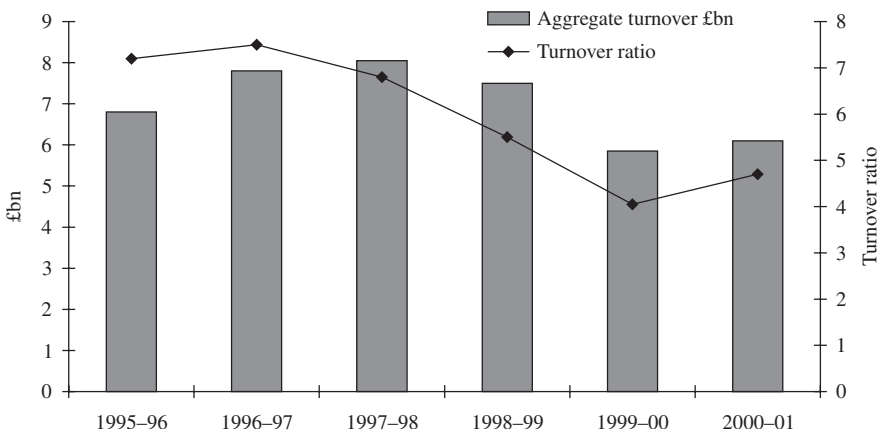


Figure 3.8: Aggregate daily turnover in gilts and turnover ratio.

### **3.12.3 Gilt price information**

As part of its aim to introduce greater transparency in the gilt market, the DMO introduced a real-time price screen on its wire services in September 2000. The screen displays indicative mid-prices for benchmark gilts, which are derived from GEMM reported prices.

### **3.12.4 Private client guide**

The wholesale market in gilts is, unsurprisingly, the dominant factor in the gilt market and the focus of the majority of analysis and comment. Nevertheless private client involvement in the gilt market is significant and should not be ignored; and the number of bargains in the retail market exceeds that in the wholesale market.<sup>17</sup>

Although the layman might think the safest place for his money is in a bank account, in fact the safest investment is in gilts. A holding in gilts is guaranteed to be paid back, and can be accessed at any time with no notice. Of course, there is a risk of loss if the gilt is not held to maturity, which is why it is important for people to be familiar with bonds in general before investing in them. But they are surely a must for every person's savings.

The majority of business in the private client sector is sourced from stockbrokers. For small investors though, a handy way to buy and sell gilts is via the Post Office. Previously this was known as the National Savings Stock Register, but is now a branch of National Savings, the government savings bank for private investors. To apply, one obtains an application form from any branch of Post Office Counters Limited, and sends this in, by means of the accompanying pre-paid envelope, to National Savings, together with a cheque for the amount. Applications can be for an amount of actual cash invested, or as nominal of stock (in which case an "open" cheque must be submitted). An attraction of National Savings is that a relatively low level of commission is charged: investors pay only £1 for up to £250 of value invested, and £0.50 for every £125 of investment thereafter. For sales of gilts, the commission is £0.10 for every £10 nominal up to £100, £1 for sales of between £100 and £250, and £0.50 for every £125 after this. Investors may purchase up to £25,000 of one specific issue on any one day.

The low commission rate reflects the low cost of operation for the government, but also the fact that there is no advice available at National Savings. They are in effect an execution-only broker (although one is dealing direct here, not via a broker). Another key difference is that because the application is made in the post, the investor will not know the final dealing price, and it will be at least a day or so from the last published price. This is not really an issue for small holdings of gilts, because price volatility is rarely excessive.

It is legal to sell a holding of gilts directly to another private individual, as long as the transaction is properly registered.

### **3.12.5 Taxation**

Gilts purchased through National Savings pay gross interest. However the coupon on gilts is taxable, so private holders will need to declare the coupon interest on their tax return. Gilts are free of capital gains tax, so higher-rate taxpayers frequently invest in them when they are expecting capital gains on their holdings.

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<sup>17</sup> Generally the term "retail" refers to private client (individual) business, but certain market makers refer to institutional business as "retail" business.

# Appendices

## Appendix 3.1: Summary statistics on the gilt portfolio (June 2002)

Nominal value	£280.7 billion
Market value	£308.9 billion
Weighted average market yield:	
Conventional gilts	4.88%
Index-linked gilts	2.22%
Average maturity	11.26 years
Average modified duration:	
Conventional gilts	6.91
Index-linked gilts	10.55
Average nominal value outstanding	£10.1 billion
(Largest 20 issues)	
(Source: DMO)	

## Appendix 3.2: Formula for the calculation of accrued interest using the actual/actual day-count basis

From 1 November 1998 the day-count basis for calculating accrued interest on gilts was changed from the actual/365 market convention to the actual/actual basis. For conventional gilts the accrued interest calculation uses the following formula and is rounded to the nearest penny.

### *Standard dividend periods*

Where the settlement date falls on or before the ex-dividend date:

$$AI = \frac{t}{n} \times \frac{C}{2}$$

Where the settlement date falls after the ex-dividend date:

$$AI = \left( \frac{t}{n} - 1 \right) \times \frac{C}{2}$$

where

- $C$  is the coupon rate
- $t$  is the number of days from the last dividend date to the settlement date
- $n$  is the number of days in the full coupon period in which the settlement date occurs.

**Short first dividend periods**

Where the settlement date falls on or before the ex-dividend date:

$$AI = \frac{t^*}{n} \times \frac{C}{2}$$

Where the settlement date falls after the ex-dividend date:

$$AI = \left( \frac{t^* - s}{n} \right) \times \frac{C}{2}$$

where

- $t^*$  is the number of days from the issue date to the settlement date
- $s$  is the number of days from the issue date to the next short coupon date.

**Long first dividend periods**

In the case of a new-issue stock with a long first coupon period the accrued interest calculation uses the following formulae. The procedure involves splitting the period between the issue date and the dividend payment date into the bond's coupon periods. This leads to a change in the rate of accrual on the theoretical coupon payment between the issue date and the long first dividend period.

Where the settlement date falls during the first coupon period:

$$AI = \frac{t}{n_1} \times \frac{C}{2}$$

Where the settlement date falls during the second coupon period on or before the ex-dividend date:

$$AI = \left( \frac{s_1}{n_1} + \frac{s_2}{n_2} \right) \times \frac{C}{2}$$

Where the settlement date falls during the second coupon period after the ex-dividend date:

$$AI = \left( \frac{s_2}{n_2} - 1 \right) \times \frac{C}{2}$$

where

- $t$  is the number of days from the issue date to the settlement date in the first coupon period (this applies only if the gilt settles in the first coupon period)
- $n_1$  is the number of days in the full coupon period in which the issue date falls
- $n_2$  is the number of days in the full coupon period after the coupon period in which the issue date falls
- $s_1$  is the number of days from the issue date to the next (theoretical) coupon date
- $s_2$  is the number of days from the (theoretical) coupon date after the issue date to the settlement date in the coupon period after the coupon period in which the issue date occurs (this applies only if the gilt settles in the second coupon period).

### Appendix 3.3: Gilt-Edged Market Makers as at April 2001. Source: DMO

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ABN Amro Bank NV	Lehman Brothers International (Europe)*
Barclays Capital*	Merrill Lynch International*
Credit Suisse First Boston Gilts Limited	Morgan Stanley & Co. International Limited
Deutsche Morgan Grenfell	Royal Bank of Canada (Europe) Ltd
Dresdner Kleinwort Benson*	Royal Bank of Scotland*
Goldman Sachs International Limited	Salomon Smith Barney
HSBC Greenwell*	UBS Warburg
JP Morgan Chase Bank	Winterflood Securities

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\*Indicates IG GEMM status.

### Gilt inter-dealer brokers as at May 2002. Source: DMO

BrokerTec Europe Limited  
Cantor Fitzgerald International  
Dowgate  
Garban-Intercapital WCLK Ltd

### Appendix 3.4: DMO reference prices

All GEMMs supply closing bid and offer clean prices for conventional gilts, except for those gilts with less than £410 million nominal outstanding. IG GEMMS also supply prices for I-L gilts. In the case of gilt strips the market makers supply mid-market strip yields, which are converted into prices using the standard DMO formula. The prices of rump stocks are set by the DMO using the prices of liquid gilts as a reference. The basic procedure followed by the DMO is to calculate the median price for each gilt from the range of prices; outlying prices are excluded before an arithmetic average price is calculated from the remaining prices. For conventional gilts, which include double-dated and undated gilts, the margin for outlying prices is £0.15, for floating-rate gilts it is £0.03, for I-L gilts it is £0.20 and for strips it is £0.30. The averaged prices are rounded to two decimal places, and are then adjusted to dirty prices using the interest accrued for that gilt to the next settlement day. Final dirty prices and strip prices are calculated to two decimal places.

The reference gross redemption yields are then calculated from the reference prices. For I-L gilts the yield calculation assumes an inflation rate of 3%. Yields are rounded to three decimal places.

The rounded average clean price, the rounded dirty price and the gross redemption yield for each gilt are displayed on the DMO's news screens.

**Example: Calculation of DMO reference price**

- ◆ The stock is the 7% Treasury 2002, closing prices on 20 October 1999, with settlement on 21 October 1999. The clean prices contributed from nine GEMMs are set out below.

101.39, 101.42, 101.47, 101.48, 101.55, 101.58, 101.61, 101.65, 101.71.

The median price is therefore 101.55. The “outlier” limit for the stock is £0.15, therefore we reject any prices greater than this amount away from the median. This leaves us with the remaining prices.

**Appendix 3.5: Growth of the UK national debt**

Year	National debt (£ million)	Year	National debt (£ million)
1694	1.2	1975	45,260
1697	15	1980	95,314
1727	53	1985	158,029
1783	232	1988	197,430
1815	900	1989	197,320
1855	805	1992	214,528
1914	651	1993	248,839
1918	5,872	1994	306,871
1940	7,900	1995	349,163
1945	21,365	1996	390,683
1955	26,934	1997	419,546
1965	30,441	1998	418,431

**Table 3.4:** UK national debt. (Source: DMO 1999).

**Appendix 3.6: Related gilt market web sites and screens**

UK Debt Management Office	<a href="http://www.dmo.gov.uk">http://www.dmo.gov.uk</a>
HM Treasury	<a href="http://www.hm-treasury.gov.uk">http://www.hm-treasury.gov.uk</a>
Bank of England	<a href="http://bankofengland.co.uk">http://bankofengland.co.uk</a>
LIFFE	<a href="http://www.liffe.com">http://www.liffe.com</a>
London Stock Exchange	<a href="http://www.londonstockex.co.uk">http://www.londonstockex.co.uk</a>

Information	Reuters/Bridge/ADP	Telerate	Topic	Bloomberg
Index	DMO/INDEX			DMO<GO>
Announcements	DMO/GILTS1 to 7	22550 to 22556	44700 to 44710	DMO1<GO>
Shop window general info	DMO/GILTS8	6515	44715	DMO2<GO>
Shop window 1	DMO/GILTS9	6516	44716	DMO3<GO>
Shop window 2	DMO/GILTS10	6517	44717	DMO4<GO>
Shop window 3	DMO/GILTS11	6518	44718	DMO5<GO>
Benchmark prices	DMO/BENCH1	22557	44720 to 44721	DMO10<GO>
GEMMA ref prices (Conventional)	GEMMA01 to 04	47216 to 47219	44800 to 44802	DMO6<GO>
GEMMA ref prices (I-L)	GEMMA08	47223	44805	DMO6<GO>
GEMMA ref prices (Strips)	GEMMA13 to 21	21291 to 21299	44850 to 44863	DMO7<GO>
Cash announcements	DMO/CASH01	15700 to 15709	44660 to 44669	DMO9<GO>
T-bill tender information	DMO/CASH11	15710 to 15711	44670 to 44671	DMO9<GO>
Ad-hoc tender information	DMO/CASH16	15715 to 15716	44675 to 44676	DMO9<GO>

**Table 3.5:** DMO wire services and news screens as at December 2002 (Source: *DMO Quarterly Review*).

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**Moorad Choudhry**

13/01/2003 13:22

Structured Finance Services, Sales and Marketing GDP 777 2066

To: Moorad Choudhry

cc:

Subject: YOU'VE BEEN CHOUDHRY'D

Morning sir,

you've been choudhry'd would be said to the unfortunate broker that

1. would go to lift or hit a trade and be second

2. to be dropped on a swap

3. if you were to be faced after a trade

4. if your broker tried to pull one of your bids or offers on your instructions

and you were hit or lifted in the process.

5. if you put up a support price and your broker never pulled the price when the market moved.

6. if u put up a swap someone sizes you up and proceeds to do absolutely nothing

...or improves your terms.

i hope these will be useful in your forthcoming book.

ps should yr book be made into a film, can i have the leading part!

cheers geez

luv ya.s. xxxxx

**Moorad Choudhry**

13/01/2003 13:24

Structured Finance Services, Sales and Marketing GDP 777 2066

To: Moorad Choudhry

cc:

Subject: Re: YOU'VE BEEN CHOUDHRY'D

glad you liked,

faced = lets say you lift a .25 offer and buy your required amount, if the sel

ler thinks it was a high lift and had more to go he may well offer them cheaper

than what you paid for them .24 ,23 etc...facial. obv the same bid side.ta.

Cut the cackle and get me out of this before I go crazy!

– Captain Haddock, *Prisoners of the Sun*  
Georges Remi (1907–1982)

# 4 The Gilt-Edged Market II: Index-Linked Gilts

In this chapter we look at index-linked gilts, which are much more recent products compared to conventional gilts, and whose return is linked to inflation rates.

## 4.1 Index-linked gilts

A major gilt instrument is the *index-linked* (I-L) gilt, or “linker”. The United Kingdom was one of the first countries to introduce index-linked government bonds, with an issue in 1981. I-L gilts are designed to provide investors with an inflation-protected, real return from their bondholding. In March 1999 approximately 21% of gilts in issue were linkers. I-L gilts link both their coupon and redemption payments to the UK retail prices index (RPI) and this adjustment should in theory preserve the real value of investors’ income and capital, independent of the rate of inflation. The RPI figure for eight months prior to the relevant cash flow is used to adjust the final value of each payment as it becomes due. To adjust a coupon payment therefore, the nominal value (this is the coupon rate) is adjusted using the RPI value recorded eight months prior to the bond’s issue date and the RPI value recorded eight months prior to the coupon payment date.

The use of an earlier RPI index level, known as an “indexation lag”, is due to the fact that the actual cash flow needs to be known six months before it is paid, so enabling the accrued interest on the bond to be calculated during the interest period. This accounts for six months of the lag; RPI figures themselves are always issued one month after the month to which they relate (for instance, September’s RPI is issued in October) and one extra month is allowed for any delay in publication of the RPI. The final redemption is treated in the same way. The existence of this indexation lag means that in practice I-L gilt returns are not completely protected from inflation, as they are unprotected in their last eight months.

The coupon level for I-L gilts is typically 2% or 2½%, which is lower than conventional gilts issued since the 1950s. This reflects the fact that, as the coupon is protected from inflation the nominal coupon value is the real interest rate expected during the bond’s life. Historically the real return on gilt stock has been around 2–3%. The importance of indexed gilts in the market as a whole reflects the attraction that such debt has for investors. Index-linked stock allows both issuers and bondholders to reduce or eliminate the risk posed by unexpected changes in inflation to the real value of their obligations and liabilities. To the extent that either the UK government or investors are averse to this risk, this represents a market gain. From the government’s point of view indexed debt offers benefits in terms of potentially contributing to

a reduction of costs and risks. For the investor the principal attractions are the hedge against inflation, which is valuable from the point of view of investors with their own indexed liabilities, plus the opportunity to trade the bonds as part of a view on real interest rates.

The market analyses the trading patterns and yield levels of index-linked gilts for their information content. The difference between the yield on I-L gilts and conventional gilts of the same maturity is an indication of the market's view on future inflation; where this difference is historically low it implies that the market considers that inflation prospects are benign. So the yield spread between I-L gilts and the same maturity conventional gilt is roughly the market's view of expected inflation levels over the long term. For example on 3 November 1999 the ten-year benchmark, the 5¾% Treasury 2009 had a gross redemption yield of 5.280%. The ten-year index-linked bond, the 2½% I-L Treasury 2009<sup>1</sup> had a *money yield* of 5.046% and a real yield of 2.041%, the latter assuming an inflation rate of 3%. Roughly speaking this reflects a market view on inflation of approximately 3.24% in the ten years to maturity. Of course other factors drive both conventional and I-L bond yields, including supply and demand, and liquidity. Generally conventional bonds are more liquid than I-L bonds. An increased demand will depress yields for the conventional bond as well.<sup>2</sup> However, the inflation expectation will also be built into the conventional bond yield and it is reasonable to assume the spread to be an approximation of the market's view on inflation over the life of the bond. A higher inflation expectation will result in a greater spread between the two bonds, reflecting a premium to holders of the conventional issue as a compensation against the effects of inflation. This spread has declined slightly from May 1997 onwards, the point at which the government gave up control over monetary policy and the Monetary Policy Committee (MPC) of the BoE became responsible for setting interest rates.

Table 4.1 shows the real yield of the 2½% I-L 2009 bond at selected points since the beginning of 1997, alongside the gross redemption yield of the ten-year benchmark conventional bond at the time (we use the same I-L bond because there was no issue that matured

Yields (%)								
Bonds	Feb-97	Jun-97	Feb-98	Jun-98	Feb-99	Jun-99	Sep-99	Nov-99
2.5% I-L 2009*	3.451	3.707	3.024	2.880	1.937	1.904	2.352	2.041
7.25% 2007	7.211	7.021	–	–	–	–	–	–
9% 2008	–	–	5.959	5.911	–	–	–	–
5.75% 2009	–	–	–	–	4.379	4.907	5.494	5.280
Spread	3.760	3.314	2.935	3.031	2.442	3.003	3.142	3.239

**Table 4.1:** Real yield on the 2½% I-L 2009 versus the ten-year benchmark.

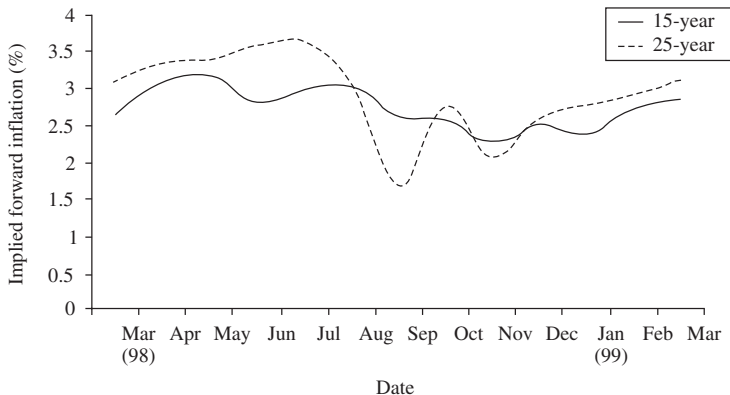
(Source: Bloomberg). \* Real yield, assuming 3% rate of inflation.

<sup>1</sup> This bond was issued in October 1982; as at October 1999 there was £2.625 billion nominal outstanding.

<sup>2</sup> For example two days later, following a rally in the gilt market, the yield on the conventional gilt was 5.069%, against a real yield on the linker of 1.973%, implying that the inflation premium had been reduced to 3.09%. This is significantly lower than the premium just two days later, which may reflect the fact that the MPC had just raised interest rates by ¼% the day before, but the rally in gilts would impact the conventional bond more than the linker.

in 2007 or 2008). Although the market's view on expected inflation rate over the ten-year period is on the whole stuck at around the 3% level, there has been a downward trend in the period since the MPC became responsible for setting interest rates. As the MPC has an inflation target of 2.5%, the spread between the real yield on the ten-year linker and the ten-year conventional gilt implies that the market believes that the MPC will achieve its goal.<sup>3</sup>

The yield spread between I-L and conventional gilts fluctuates over time and is influenced by a number of factors and not solely by the market's view of future inflation (the implied forward inflation rate). As we discussed in the previous paragraph, however, the market uses this yield spread to gauge an idea of future inflation levels. The other term used to describe the yield spread is *breakeven inflation*, that is the level of inflation required that would equate nominal yields on I-L gilts with yields on conventional gilts. Figure 4.1 shows the implied forward inflation rate for the 15-year and 25-year terms to maturity as they fluctuated during 1998/1999. The data is from the BoE. For both maturity terms, the implied forward rate decreased significantly during the summer of 1998; analysts, however, ascribed this to the rally in the conventional gilts, brought on by the "flight to quality" after the emerging markets fallout beginning in July that year. This rally was not matched by I-L gilts performance. The 25-year implied forward inflation rate touched 1.66% in September 1999, which was considered excessively optimistic given that the BoE was working towards achieving a 2.5% rate of inflation over the long term! This suggested that conventional gilts were significantly overvalued.<sup>4</sup> As we see in Figure 4.1, this implied forward rate for both



**Figure 4.1:** UK implied forward inflation rates during 1998/99. (Source: BoE).

<sup>3</sup> In fact the MPC target centres on the RPIX measure of inflation, the "underlying" rate. This is the RPI measure but with mortgage interest payments stripped out.

<sup>4</sup> As we have noted, the yield spread between I-L and conventional gilts reflects other considerations in addition to the forward inflation rate. As well as specific supply and demand issues, considerations include inflation risk premium in the yield of conventional gilts, and distortions created when modelling the yield curve. There is also a liquidity premium priced into I-L gilt yields that would not apply to benchmark conventional gilts. The effect of these is to generally overstate the implied forward inflation rate. Note also that the implied forward inflation rate applies to RPI, whereas the BoE's MPC inflation objective targets the RPIX measure of inflation, which is the headline inflation rate minus the impact of mortgage interest payments.

maturity terms returned to more expected levels later during the year, slightly above 3%. This is viewed as more consistent with the MPC's target, and can be expected to fall to just over 2.5% over the long term.

#### **Example 4.1: I-L gilt cash flow calculation**

As with conventional gilts, I-L gilts pay coupon on a semi-annual basis. Coupons are linked to the retail price index. To calculate any coupon payment and the redemption payment for an I-L gilt we require the RPI value for eight months prior to the issue of the bond and the value for eight months prior to the cash flow date. The BoE carries out and publishes the calculations for each I-L gilt.

Coupon and redemption payments are calculated using (4.1) and (4.2).

$$\frac{C}{2} \times \frac{RPI_C}{RPI_I} \quad (4.1)$$

$$100 \times \frac{RPI_M}{RPI_I} \quad (4.2)$$

where

$RPI_I$  is the RPI value recorded eight months prior to the bond issue date

$RPI_C$  is the RPI value recorded for the month eight months prior to the coupon date

$RPI_M$  is the RPI value recorded eight months prior to the maturity date.

$RPI_I$  is also known as the *base RPI* value. A table of RPI values is given at Appendix 4.2.

The 2½% index-linked Treasury 2024 stock was issued in December 1986. Therefore the base RPI figure for this bond is 97.67, which is the index value for March 1986, published in April 1986. The bond has coupon dates each January and July, so to calculate the coupons we require the RPI values for the previous May and November respectively. The coupon payment in July 1999 was calculated as follows:

$$\frac{2.5}{2} \times \frac{164.4}{97.67} = 2.1040$$

The RPI values used are those for April 1986 (the base RPI) and November 1998. Note that 164.4 is the RPI for October 1998, published one month later.

The bond's maturity date is 17 July 2024. The redemption payment for this bond will be calculated using the expression given below:

$$100 \times \frac{RPI_{Nov2023}}{RPI_{Apr1986}}$$

The usual measure of return used with gilts is the yield to maturity or gross redemption yield. The yield calculation for I-L gilts assumes a constant level of inflation in order to fix the cash flows, which enables us to calculate the redemption yield. This is usually carried out using the current RPI level and then assuming a constant inflation rate from then on, scaling the RPI values up accordingly. The yield calculated using this method is often

referred to as a *nominal yield*. The nominal yield reflects the assumed level of inflation, usually fixed at 3% or 5% by analysts in the sterling markets. In order to gauge an idea of the real return, the nominal yield is sometimes adjusted to give a real yield using the Fisher equation.<sup>5</sup> The DMO<sup>6</sup> uses the following form of the Fisher identity in its calculations:

$$\left(1 + \frac{r}{200}\right)^2 = \frac{(1 + (y/200))^2}{(1 + (i/100))} \quad (4.3)$$

where

- $r$  is the real yield (%)
- $y$  is the nominal yield (%)
- $i$  is the assumed inflation rate (%).

The other yield calculation used in I-L gilt analysis is that for real redemption yield. The DMO in its *Gilt Review* 1998 uses equation (4.4) to calculate real yields, given that there is an indexation lag used in computing actual cash flows, based on the need to calculate accrued interest for a forthcoming interest period, and the delay inherent in publishing the RPI figure itself. As the DMO notes, this lag introduces a complication in real yield calculation, and also requires an assumed constant inflation rate to be used when computing real redemption yields.<sup>7</sup>

$$P = \frac{d_1}{\left(1 + \frac{r}{2}\right)^{\frac{r}{s}} \left(1 + i_0\right)^{\frac{r}{2s} - \frac{1}{6}} \left(1 + i_1\right)^{\frac{1}{6}}} + \frac{\frac{C}{2} \times \frac{RPI_{latest}}{RPI_{base}} (1 + i_0)^{\frac{k}{12}}}{\left(1 + \frac{r}{2}\right)^{\frac{r}{s} + 1} \left(1 + i_0\right)^{\frac{r}{2s} - \frac{1}{6}} \left(1 + i_1\right)^{\frac{1}{2}} \left(1 + i_2\right)^{\frac{1}{6}}} \\ + \frac{\frac{C}{2} \times \frac{RPI_{latest}}{RPI_{base}} (1 + i_0)^{\frac{k}{12}} (1 + i_1)^{\frac{1}{2}}}{\left(1 + \frac{r}{2}\right)^{\frac{r}{s} + 2} \left(1 + i_0\right)^{\frac{r}{2s} - \frac{1}{6}} \left(1 + i_1\right)^{\frac{1}{2}} \left(1 + i_2\right)^{\frac{1}{2}} \left(1 + i_3\right)^{\frac{1}{6}}} + L \quad (4.4)$$

where

- $P$  is the bond dirty price
- $C$  is the real coupon
- $L$  is the gross real redemption yield
- $i_j$  is the future annual inflation rate for period  $j$
- $RPI_{latest}$  is the last published RPI
- $RPI_{base}$  is the RPI relating to eight months prior to bond issue date
- $d_1$  is the next dividend payment
- $r$  is the number of days from the settlement date to the next dividend date
- $s$  is the number of days in the interest period in which the settlement date falls
- $k$  is the number of months between latest RPI at time of settlement and the month of the RPI that defines the next but one dividend payment.

<sup>5</sup> The Fisher identity states that nominal yield comprises real yield and expected inflation, given in its simplest form as  $(1 + y) = (1 + r) \times (1 + i)$ .

<sup>6</sup> *Review*, 1998.

<sup>7</sup> Note that equations (4.3) and (4.4) use the DMO's terminology.

Equation (4.4) assumes that the bond does not settle during the ex-dividend period. It simplifies to (4.5):

$$P = \frac{d_1}{\left(1 + \frac{r}{2}\right)^{\frac{r}{s}} (1 + i_0)^{\frac{r}{2s} - \frac{1}{6}} (1 + i_1)^{\frac{1}{6}}} + \frac{\frac{C}{2} \times \frac{RPI_{Interest}}{RPI_{base}}}{\left(1 + \frac{r}{2}\right)^{\frac{r}{2} + 1} (1 + i_0)^{\frac{r}{2s} - \frac{1}{6} - \frac{k}{12}} (1 + i_1)^{\frac{1}{2}} (1 + i_2)^{\frac{1}{6}}} + \frac{\frac{C}{2} \times \frac{RPI_{Interest}}{RPI_{base}}}{\left(1 + \frac{r}{2}\right)^{\frac{r}{s} + 2} (1 + i_0)^{\frac{r}{2s} - \frac{1}{6} - \frac{k}{12}} (1 + i_2)^{\frac{1}{2}} (1 + i_3)^{\frac{1}{6}}} + L \quad (4.5)$$

From (4.5) we observe that the terms for the future rate of inflation in the numerator and denominator do not cancel out completely. This is due to the indexation lag. This is why it is necessary to assume a constant inflation rate for all forward coupon calculations, given by  $i_0, i_1, i_2$ , and so on to  $i_n$  in order to calculate the real redemption yield. If we assume a constant inflation rate of  $p^e$  for all rates of inflation during the life of a bond, equation (4.5) becomes (4.6) below, using the DMO's terminology.

$$P = \frac{d_1}{\left(1 + \frac{r}{2}\right)^{\frac{r}{s}} (1 + p^e)^{\frac{r}{2s}}} + \frac{\frac{C}{2} \times \frac{RPI_{Interest}}{RPI_{base}}}{\left(1 + \frac{r}{2}\right)^{\frac{r}{s} + 1} (1 + p^e)^{\frac{r}{2s} - \frac{k}{12} + \frac{1}{2}}} + \frac{\frac{C}{2} \times \frac{RPI_{Interest}}{RPI_{base}}}{\left(1 + \frac{r}{2}\right)^{\frac{r}{s} + 2} (1 + p^e)^{\frac{r}{2s} - \frac{k}{12} + \frac{1}{2}}} + L \quad (4.6)$$

In addition to the process given by (4.4), another method used to calculate values given assumed inflation rates is to use the forward inflation rates implied by the difference between points on the nominal yield curve and the real yield curve. In the UK market the convention is to assume a constant inflation rate of 3%, although often analysts compute yields using both 3% and 5% assumed inflation. Using a higher inflation rate results in a lower real yield value.

In other index-linked bond markets, the calculation difficulty in computing real yields is removed by assuming that it is equal to zero, so that the inflation terms in (4.6) cancel out. Analysts in the US index-linked market for example, sometimes use this method to calculate real yields. This may have less impact since the indexation lag in the US market, at three months, is shorter than in the UK.

#### Example 4.2: Real yields versus conventional gross redemption yields

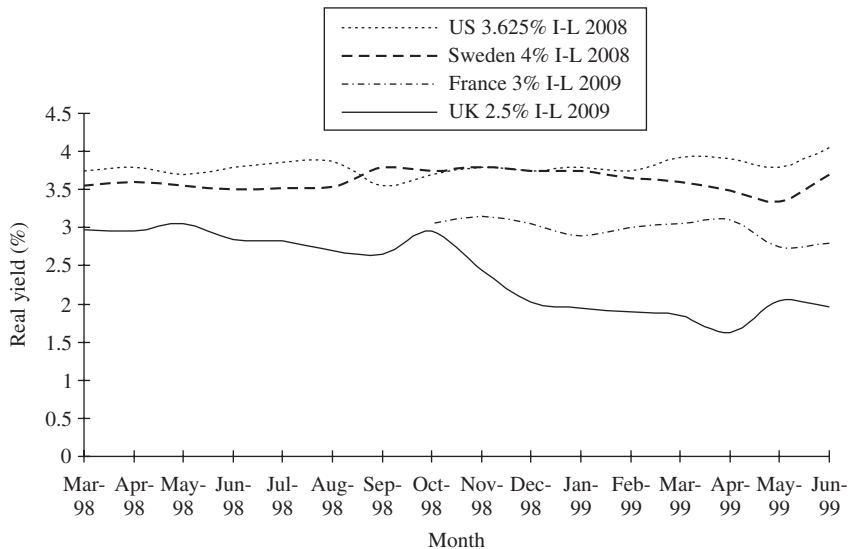
On 10 October 1999 the 2% I-L Treasury 2006 gilt is trading at £231.90, a real yield of 2.209% (assuming an inflation rate of 3%). A double-dated gilt, the 3½% Funding 1999–2004, is trading at £92.72 which is equivalent to a gross redemption yield of 5.211%, assuming the stock is redeemed at the final maturity date. A private investor currently holding the I-L gilt is recommended by their stockbroker to switch into the double-dated issue. The investor is a higher-rate taxpayer, and there is no capital gains tax to pay on gilt investments. Do you agree with the stockbroker's recommendation? What reasons lie behind your decision?

In order to compare the two gilts we need to make an assumption about future inflation. The yield spread between the two bonds implies a forward inflation rate of just over 3%. Therefore if the actual inflation rate to 2004 averages more than 3%, the investor would have been better served by the I-L gilt. At a price of £92.72 the conven-

tional gilt offers a capital gain on maturity of £7.28. The coupon on the investment is only 3.50% however. Compare this with an expected coupon of 4.50% for the I-L bond, if we assume that inflation will stay at or around the MPC's target rate of 2.5%. On maturity, however, the price of the I-L gilt will be £169.00, which we calculate using the current RPI level until maturity (this gives us  $165.1 \times 1.0257$ ) and assuming 2.5% inflation to 2006. This will result in a capital loss for the investor. As there is income tax to pay on gilts, the conventional gilt probably then is the better option for the investor who will pay tax at the higher rate on the coupon income.

However, there are a range of factors for the investor to consider, and the most significant is the extent to which they wish to protect themselves against unexpected inflation. The final decision must also consider the investor's portfolio as a whole; for example, a high level of cash holdings would imply a greater exposure to inflation, which would swing the argument in favour of holding I-L gilts.

Comparing the yield levels on indexed bonds across markets enables analysts to assess the inflation expectations in several countries at once. While this is carried out frequently, it is important to factor in the non-inflation expectation considerations that make up bond yields. A high level of demand for I-L bonds, or an overvalued conventional bond market can sometimes imply a lower forward inflation rate than is realistic. This is best illustrated using the implied forward inflation rates across four countries during 1998/1999, as shown in Figure 4.2. The inflation expectation for the UK was artificially depressed by the excessive institutional investor demand for I-L gilts, brought on in part by the Minimum Funding



**Figure 4.2:** Real yields on index-linked bonds across four countries in 1998/99. (Source: BoE).



Requirement rules, as well as “flight to quality” during the 1998 bear market in bonds that lowered gilt yields versus Bund yields.

## 4.2 Index-linked gilts analytics

Index-linked gilts were first introduced by the UK government in 1981. The authorities’ commitment to index-linked gilts was emphasised in the DMO’s gilt market review for 1998, which stated that they were to form a higher part of overall gilt sales. A formal auction calendar for index-linked stock was also established. There are currently eleven index-linked gilts in issue, with the longest dated bond maturing in 2035. A formal auction programme for index-linked gilts was set up by the DMO, with the first auction taking place in October 1998. As part of this, registration of index-linked GEMMs (IG GEMMs) was introduced by the DMO. IG GEMMs are recognised as such in the same way as conventional GEMMs; they have access to competitive bidding at IG auctions, and are in contact with the DMO over the type of stock to be scheduled for auction. The requirements for IG GEMMs are the same as for conventional GEMMs, namely active participation in auctions, providing two-way prices in all IG stocks at all times, an additional requirement to maintain a minimum 3% market share and the provision to the DMO of “relevant market information”. As part of the auction programme the DMO will supply a minimum amount of £2.5 billion of stock each year. This figure is a cash figure, not a nominal value.<sup>8</sup>

In this section we consider simple measures of inflation expectations using index-linked gilts. An understanding of market inflation expectations is of some use to practitioners and policy makers. For instance, the market-determined yield on an I-L bond, set against a government’s inflation target, gives an indication of the credibility of the target itself. The market’s expected view of inflation is also useful data for financial and industrial sector institutions when they are carrying out forward business planning. Corporate finance and project appraisal analyses that consider future cash flows and expected rates of return also build in an inflation expectation. This expectation estimate is best obtained using yields from the government bond market. Governments use inflation expectations when deciding the make-up of their funding, for example the decision on how much conventional versus index-linked debt to issue.<sup>9</sup>

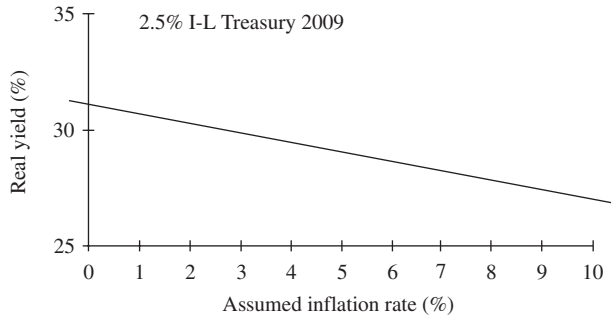
Analysts frequently use the yield levels on index-linked bonds and their value relative to conventional yields to infer market expectations of future inflation. In the past, information on inflation expectations has been obtained via surveys and theoretical models. These frequently prove unreliable. Therefore an effort has been made from the 1980s onwards to infer expectations from bond prices. In some markets an exchange-traded futures contract on a retail prices index can be traded, which would give a direct indication of the market’s expectation of future inflation rates.<sup>10</sup> In the UK no contract of this type exists.

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<sup>8</sup> I am grateful to Gurminder Bhachu at the DMO for pointing this out.

<sup>9</sup> Deacon and Derry (1994) cite the example of the Swedish central bank, the Riksbank issuing index-linked bonds for the first time because it believed that the market’s expectation on the future level of inflation was overstated, which would make the yield on index-linked bonds lower than that on conventional bonds, thus resulting in a saving on borrowing costs for the government.

<sup>10</sup> For example, Deacon and Derry (*ibid*) describe a Consumer Price Index futures contract traded on the New York Coffee, Sugar and Cocoa Exchange in the 1980s.



**Figure 4.3:** Sensitivity of I-L gilt real yield and assumed inflation rate.

However, because of the existence of index-linked bonds we do have an indication of the market's view on inflation, albeit an indirect one. Several studies have analysed the information content of yields in the I-L gilt market, among them Deacon and Derry (1994) and Woodward (1990).

In analysing I-L gilts we note that the instruments do not offer complete protection from inflation, due to the eight-month lag in the indexation formula. Therefore when we calculate the real redemption yield for I-L gilts we must make an assumption about future inflation, both the level itself and that it remains constant. This enables us to write the expression for the I-L bond price/yield relationship, if we simplify the arrangement to a six-month (rather than eight-month) indexation lag.

$$P = \frac{(1+i)C}{(1+i_a)(1+r)} + \frac{(1+i)C}{(1+i_a)(1+r)^2} + \dots + \frac{(1+i)(C+M)}{(1+i_a)(1+r)^n} \quad (4.7)$$

where

- $C$  is the coupon
- $M$  is the redemption proceeds on maturity (par)
- $r$  is the gross real yield
- $i$  is the known RPI inflation used to set the next coupon payment
- $i_a$  is the assumed average future inflation rate over the term to maturity.

To obtain the *net* real redemption yield we use the net coupon payment, which is calculated using  $C \times (1 - t)$ , where  $t$  is the rate of income tax.

The need to assume a constant future inflation rate becomes significant when we estimate and construct a real yield curve, or term structure of real interest rates. This is because the level of the assumed inflation rate obviously has an impact on the real yield that is calculated. Figure 4.3 shows the relationship between the assumed inflation rate and the real yield for the 2½% I-L Treasury 2009 in October 1999. The yield calculations were performed on a Bloomberg terminal.

### 4.3 Calculating break-even inflation

Two methods for deriving inflation expectations from gilt prices are described in Deacon and Derry (1994). The first is the "simple" method. In this approach average expected

inflation is calculated using the *Fisher identity*. By the Fisher equation we calculate the expected inflation rate as the spread between the real yield on the I-L gilt, which has been calculated using an assumed constant rate of inflation, and the yield to maturity of a conventional gilt of the same maturity. We observed this earlier in Section 4.1 when we compared the real yield on the 2½% I-L Treasury 2009 with the redemption yield on the 5¾% Treasury 2009. This yield spread is an estimate of the average expected rate of inflation over the ten years from 1999. A common error is to interpret the yield spread as the expected inflation rate in ten years' time (in our example using the 2½% I-L Treasury 2009), which is incorrect, and not the average rate during the next ten years. However, this inflation measure is at best a rough expected approximate measure, with ultimately little value. This is because the real yield measure for an I-L bond is itself calculated using an assumption of an average rate of inflation, which yield is then used to estimate an inflation expectation. Thus this measure uses an inflation expectation to estimate an inflation expectation! Deacon and Derry refer to this as a *lack of internal consistency*.

Another simple method is calculating break-even inflation rates. In this approach an average inflation expectation is estimated by comparing the yield on a conventional gilt to that on an I-L gilt of the same (or similar) maturity, and applying the compound form of the Fisher equation. This means that we decompose the nominal yield on a bond into components of real yield and rate of inflation, using compound interest rules. For the UK market, which uses semi-annual coupon compounding, the expression is given at (4.8):

$$\left(1 + \frac{y}{2}\right) = (1 + i)^{\frac{1}{2}} \times \left(1 + \frac{r}{2}\right) \quad (4.8)$$

where

- $y$  is the nominal yield
- $r$  is the real yield
- $i$  is the rate of inflation.

The break-even approach implicitly assumes that investors treat conventional and I-L bonds the same and do not demand an inflation or liquidity risk premium for holding either type of bond. That is, they are risk-neutral. Under this assumption a conventional bond and index-linked bond will have the same nominal yield. Under this scenario of equal nominal yields, we can use the conventional bond yield instead of the I-L yield, which enables us to use the I-L bond price/yield formula and the Fisher equation to solve for the real yield and the expected rate of inflation. Such an approach was used in the study by Arak and Kreicher (1985). In their study a 0% tax rate is used as a zero risk premium, although the base RPI level is that in place at the time of issue, whereas for I-L gilts it is the RPI in place eight months prior to issue that is actually used in calculations.

## 4.4 Duration matching

In the two methods described above we noted that conventional and I-L gilts of roughly the same maturity should be used in the analysis. Another approach is to match the two bond types by duration rather than term to maturity. This appears logical since duration equalises bonds in terms of the weighted-average maturity of their cash flows. Duration (and modified duration) is a measure of the sensitivity of a bond's price to changes in

interest rates. This measure can be interpreted also as price sensitivity to changes in expected inflation and the real interest rate, given that the real yield of a bond is a function of the expected rate of inflation.<sup>11</sup> For this reason it might be expected that gilts of equal duration should have similar yields. However, a drawback to matching gilts by duration arises if the two bonds selected differ significantly in their terms to maturity, so that their yields are dissimilar. For example consider the following measures for two gilts on 9 November 1999<sup>12</sup>:

*2½% I-L Treasury 2009*

Real yield adjusted duration:	8.386
Inflation adjusted duration:	8.262
Real yield:	1.967% (assuming average inflation of 3%)
Money yield:	4.972%

The conventional gilt with the nearest duration measure is the 9% Treasury 2012.

*9% Treasury 2012*

Duration:	8.426
Gross redemption yield:	5.109%

The conventional gilt has a term to maturity three years greater than the I-L bond. A calculation of the break-even inflation rate using the yields from these two bonds could be argued to be the average expected rate of inflation over either 10 years or 13 years.

The same problem associated with calculating the real yield for an I-L gilt arises in duration matching. The formula for calculating duration uses the present value of a bond's cash flows. The cash flows for an I-L gilt can only be known if we assume an average inflation rate for the term to maturity. Just as with the real yield measure, the duration and modified duration of an I-L gilt is sensitive to a change in the assumed inflation rate. Several commentators have suggested that using duration matching should be avoided, including Bootle (1991) and Woodward (1990). The reason for this is because holders of conventional bonds face what is termed nominal interest rate risk, that is the risk of a change in real interest rates or inflation expectations, whereas I-L bondholders are exposed to real interest rate risk only. The two bond types therefore expose investors to unequal risks. Duration matching is only effective for instruments that are exposed to the same risks.

The break-even approach to obtaining a measure of inflation expectation is at best a rough approximation, and the underlying assumptions behind its calculation render it of little use to market practitioners and policy makers. The main issues are:

- the assumption that gilts trade with no risk or liquidity premia is not accurate, as any observation of market yields for specific bonds will confirm;
- to date there have not been a pair of conventional and I-L gilts that have identical maturity dates, forcing analysts to use approximately matching maturities. This leads to inaccuracy in the values for the real interest rate and the expected inflation rate;

<sup>11</sup> This follows the explanation given by the expectations hypothesis.

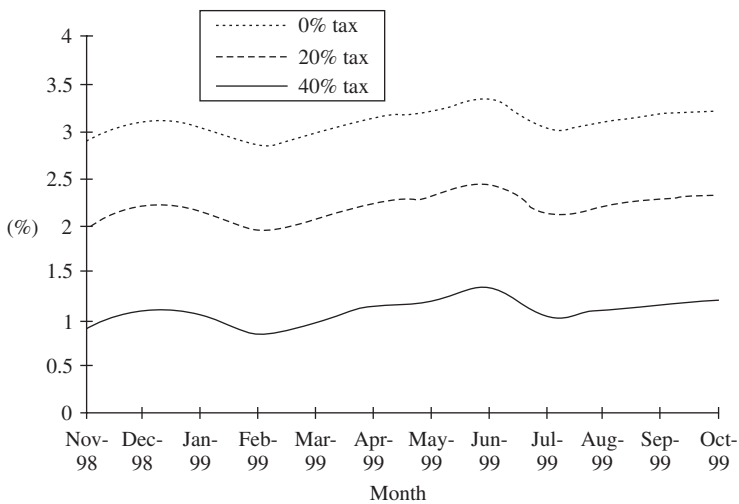
<sup>12</sup> Data obtained from Bloomberg analytics screen.

- often there is no I-L gilt maturing in a particular year;
- the tax rate used in the calculation of the break-even rate has a significant impact on the result. To produce the net real yield measure for an I-L gilt, analysts assume a marginal level of taxation, usually the basic and the higher rate of tax (20% and 40%).

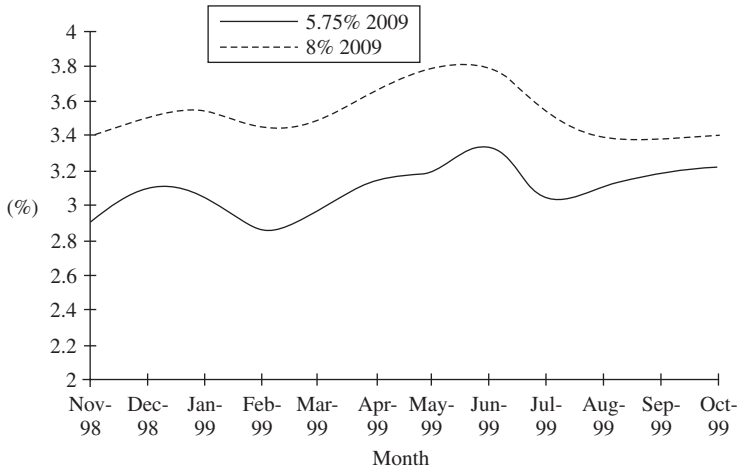
If we use break-even forward inflation rates we need to apply the appropriate rate of tax in the calculation. Figure 4.4 shows the effect of using different tax rates, using real yields for the 2½% I-L Treasury 2009 stock and the 5¾% Treasury 2009 during 1998/1999. The graph indicates that there is a significant effect on the break-even rate itself of using a different tax rate, but that the differential between the results is uniform irrespective of the tax rate used.

There are further issues to consider. Since (as in Figure 4.4) we derive the break-even inflation rate from two specific gilts, the calculation will reflect the idiosyncrasies of these two stocks. The price effect of supply and demand factors will influence the calculation. Therefore the inflation expectation using this method is peculiar to the two stocks selected and will be a different result for each pair. To illustrate consider Figure 4.5, which compares the break-even inflation rate for the 2½% I-L Treasury 2009 both when compared against the 10-year benchmark bond, the 5¾% Treasury 2009, and another stock of similar maturity, the 8% Treasury 2009. The coupon effect of the latter stock is clearly demonstrated.

Deacon and Derry (1994) have advocated using double-dated gilts in the analysis when faced with a shortage of gilts for particular maturity dates. This is acceptable because the market convention holds that a gilt trading above par will trade to the earliest maturity date, while if it is below par the bond will be redeemed at the last possible date. However, the maturity will change if the bond price moves above or below par; where this is the case using a double-dated gilt will result in distortions in the break-even inflation calculation. The yield on a double-dated bond is also not strictly comparable to that of an equivalent



**Figure 4.4:** Break-even inflation rate and effect of taxation.

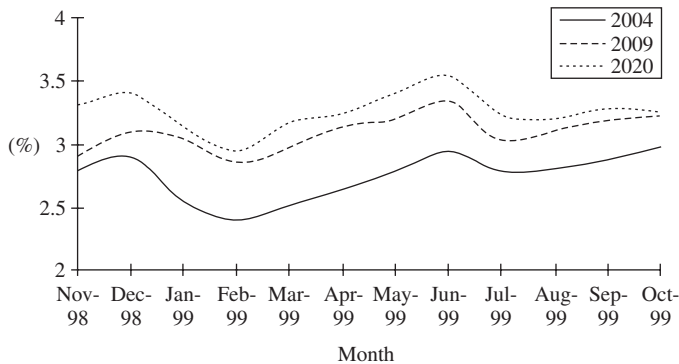


**Figure 4.5:** Sensitivity of break-even inflation rate to specific conventional stock.

maturity conventional bond (under the maturity assumption for the double-dated bond), since double-dated gilts trade cheap to the yield curve. This reflects the lower liquidity for these bonds and the premium attributable to the call feature attached to the bond, which is against investor interests.

### 4.5 An implied forward inflation rate curve

If we calculate the break-even inflation rate for every I-L gilt for the period 1998/1999, bar the 4.125% I-L 2030 (for which there is no matching maturity conventional gilt), we can arrive at an estimate of future inflation expectations over different time periods. This is illustrated in Figure 4.6. The structures are drawn as smooth curves, although with only ten I-L gilts available, this approach is problematic. This is one method by which a term



**Figure 4.6:** Break-even inflation rates over different terms to maturity.

structure of future inflation rates can be constructed. However, a forward inflation curve derived in this manner is flawed because of the small number of gilts available, and because the calculations are strictly applicable only to the specific gilts used. This restricts the use we might make of the curve. Nevertheless although the level of the future inflation expectation is not accurately reported by the curves in Figure 4.6, they can be used to indicate changes in expectations themselves.

## 4.6 The DMO's index-linked gilts redesign

Towards the end of 2001 the DMO conducted a survey amongst market participants, including I-L gilts market makers and fund managers, on whether a redesign of indexed gilts should be undertaken. This had asked, amongst other things, whether there should be a reduction in the time lag from eight months to three months, and whether the DMO should issue Limited Price Indexation bonds as well as standard RPI-linked bonds. Following the consultation, the DMO decided that the design of new issues of index-linked gilts would follow the same features as existing I-L gilts, with the exception of the following:

- there would be a new clause in the prospectus, an indexation clause, that would state that index-linked gilts will be linked to the general RPI, or any subsequent index that the Chancellor of the Exchequer, after consultation with an independent body, decides is an effective measure of the change in level of UK retail prices;
- the coupon and redemption payments of any new I-L gilt will be calculated by the DMO rather than the BoE, although the BoE would retain this function for existing gilts; new gilts would have cash flows calculated to six decimal places, rather than the current two or four decimal places;
- while no stripping facility for indexed gilts will be introduced in the near future, the DMO will consider aligning the coupon dates of future new issues, so as to help facilitate the introduction of a strips facility if required;
- coupon dates for new issues will be in January and July.

The DMO did not envisage issuing a new index-linked gilt, reflecting the outcome of the market consultation, ahead of the last quarter in 2002.

# Appendices

## Appendix 4.1: Introduction to index-linked bonds

### *Calculating index-linked yields*

In certain markets including the United Kingdom market, the government and certain corporates issue bonds that have either or both of their *coupon* and *principal* linked to a price index, such as the retail price index (RPI), a commodity price index (for example, wheat) or a stock market index.<sup>A1</sup> In the UK we refer to the RPI whereas in other markets the price index is the consumer price index (CPI). If we wish to calculate the yield on such *index-linked bonds* it is necessary to make forecasts of the relevant index, which are then used in the yield calculation. As an example we can use the case of index-linked government bonds which were first introduced in the UK in March 1981. Both the principal and coupons on UK index-linked government bonds are linked to the RPI and are therefore designed to give a constant *real* yield. When I-L gilts were first introduced the BoE allowed only pension funds to buy them, under the reasoning that these funds had index-linked pensions to deliver to their clients. However a wide range of investors are potential investors in bonds whose cash flows are linked to prices, so that shortly after their introduction all investors were permitted to hold I-L gilts. Most of the index-linked stocks that have been issued by the UK government have coupons of 2 or 2½ per cent. This is because the return from an index-linked bond represents in theory *real* return, as the bond's cash flows rise in line with inflation. Historically the real rate of return on UK market debt stock over the long term has been roughly 2½ per cent.

Indexed bonds differ in their make up across markets. In some markets only the principal payment is linked, whereas other indexed bonds link only their coupon payments and not the redemption payment. Indexed gilts<sup>A2</sup> in the UK market link both their coupons and principal payment to the RPI. Therefore each coupon and the final principal on index-linked gilts are scaled up by the ratio of two values of the RPI. The main RPI measure is the one reported for eight months before the issue of the gilt, and is known as the *base RPI*. The base RPI is the denominator of the index measure. The numerator is the RPI measure for eight months prior to the month of coupon payment, or eight months before the bond maturity date.

The coupon payment of an index-linked gilt is given by (4.9) below.

$$\text{Coupon payment} = \frac{C}{2} \times \frac{RPI_{C-8}}{RPI_0} \quad (4.9)$$

Expression (4.9) shows the coupon divided by two before being scaled up, because I-L gilts pay semi-annual coupons. The formula for calculating the size of the coupon payment for an annual-paying indexed bond is modified accordingly.

The principal repayment is given by (4.10).

$$\text{Principal repayment} = 100 \times \frac{RPI_{M-8}}{RPI_0} \quad (4.10)$$

<sup>A1</sup> "Principal" is the usual term for the maturity or redemption payment of a bond.

<sup>A2</sup> Called "linkers" in the market.



where

- $C$  is the annual coupon payment  
 $RPI_0$  is the RPI value eight months prior to the issue of the bond (the *base* RPI)  
 $RPI_{C-8}$  is the RPI value eight months prior to the month in which the coupon is paid  
 $RPI_{M-8}$  is the RPI value eight months prior to the bond redemption.

Note how in the UK gilt market the indexation calculation as given by (4.9) and (4.10) uses the RPI values for eight months prior to the date of each cash flow. This is for technical reasons, because the payment authority (in this case the BoE) needs to know each coupon payment six months before it is paid in order to determine the interest accruing between coupon payments. This would call for a time lag of at least six months. The two additional months are due to the one-month delay in publishing the RPI (for example, January's RPI is not published until February) plus additional time to make the payment calculations. The time lag is therefore eight months. Price indices are occasionally "re-based" which means that the index is set to a base level again. In the UK the RPI has been re-based twice, the last occasion being in January 1987, when it was set to 100 from the January 1974 value of 394.5.

#### Example A4.1

An index-linked gilt with coupon of 4.625% was issued in April 1988 and matured in April 1998. The base measure required for this bond is the RPI for August 1987, which was 102.1. The RPI for August 1997 was 158.5. We can use these values to calculate the actual cash amount of the final coupon payment and principal repayment in April 1998, as shown below.

$$\text{Coupon payment} = \frac{4.625}{2} \times \frac{158.5}{102.1} = \text{£}3.58992$$

$$\text{Principal repayment} = 100 \times \frac{158.5}{102.1} = \text{£}155.23996$$

We can determine the accrued interest calculation for the last six-month coupon period (October 1987 to April 1998) by using the final coupon payment, given below.

$$3.58992 \times \frac{\text{no. of days accrued}}{\text{actual days in period}}$$

The markets use two main yield measures for index-linked bonds, both of which are a form of yield-to-maturity. These are the *money* (or *nominal*) *yield*, and the *real yield*.

In order to calculate a money yield for an indexed bond we require forecasts of all future cash flows from the bond. Since future cash flows from an index-linked bond are not known with certainty, we therefore require a forecast of all the relevant future RPIs, which we then apply to all the cash flows. In fact the market convention is to take the latest available RPI and assume a constant inflation rate thereafter, usually 2½% or 5%. By assuming a constant

inflation rate we can set future RPI levels, which in turn allow us to calculate future cash flow values.

We obtain the forecast for the first relevant future RPI using (4.11).

$$RPI_1 = RPI_0 \times (1 + \tau)^{m/12} \quad (4.11)$$

where

- $RPI_1$  is the forecast RPI level
- $RPI_0$  is the latest available RPI
- $\tau$  is the assumed future annual inflation rate
- $m$  is the number of months between  $RPI_0$  and  $RPI_1$ .

Consider an indexed bond that pays coupons every June and December. For analysis we require the RPI forecast value for eight months prior to June and December, which will be for October and April. If we are now in February, we require a forecast for the RPI for the next April. This sets  $m=2$  in our equation at (4.11). We can then use (4.12) to forecast each subsequent relevant RPI required to set the bond's cash flows.

$$RPI_{j+1} = RPI_1 \times (1 + \tau)^{j/2} \quad (4.12)$$

where  $j$  is the number of semi-annual forecasts after  $RPI_1$  (which was our forecast RPI for April). For example if the February RPI was 163.7 and we assume an annual inflation rate of 2.5%, then we calculate the forecast for the RPI for the following April to be:

$$\begin{aligned} RPI_1 &= 163.7 \times (1.025)^{2/12} \\ &= 164.4 \end{aligned}$$

and for the following October it would be:

$$\begin{aligned} RPI_2 &= 164.4 \times (1.025) \\ &= 168.5 \end{aligned}$$

Once we have determined the forecast RPIs we can calculate the yield. Adopting our familiar assumption that the analysis is carried out on a coupon date, so that accrued interest on the bond is zero, we can calculate the money yield ( $ri$ ) by solving equation (4.13).

$$P_d = \frac{\left(\frac{C}{2}\right)\left(\frac{RPI_1}{RPI_0}\right)}{\left(1 + \frac{1}{2}ri\right)} + \frac{\left(\frac{C}{2}\right)\left(\frac{RPI_2}{RPI_0}\right)}{\left(1 + \frac{1}{2}ri\right)^2} + \dots + \frac{\left(\frac{C}{2} + M\right)\left(\frac{RPI_N}{RPI_0}\right)}{\left(1 + \frac{1}{2}ri\right)^N} \quad (4.13)$$

where

- $ri$  is the semi-annualised money yield-to-maturity
- $N$  is the number of coupon payments (interest periods) up to maturity.

Equation (4.13) is for semi-annual paying indexed bonds such as index-linked gilts. The equation for annual coupon indexed bonds is given at (4.14).

$$P_d = \frac{C\left(\frac{RPI_1}{RPI_0}\right)}{(1 + ri)} + \frac{C\left(\frac{RPI_2}{RPI_0}\right)}{(1 + ri)^2} + \dots + \frac{(C + M)\left(\frac{RPI_N}{RPI_0}\right)}{(1 + ri)^N} \quad (4.14)$$

The real yield ( $ry$ ) is related to the money yield through equation (4.15), as it applies to semi-annual coupon bonds, which was first described by Fisher in *Theory of Interest* (1930).

$$\left(1 + \frac{1}{2}ry\right) = \frac{(1 + \frac{1}{2}ri)}{(1 + \tau)^{\frac{1}{2}}} \quad (4.15)$$

To illustrate this, if the money yield is 5.5% and the forecast inflation rate is 2.5%, then the real yield is calculated using (4.15) as shown below.

$$\begin{aligned} ry &= \left\{ \frac{[1 + \frac{1}{2}(0.055)]}{[1 + (0.025)]^{\frac{1}{2}}} - 1 \right\} \times 2 \\ &= 0.0297 \text{ or } 2.97\% \end{aligned}$$

We can re-arrange equation (4.13) and use (4.15) to solve for the real yield, shown at (4.16) and applicable to semi-annual coupon bonds. Again, we use (4.16) where the calculation is performed on a coupon date.

$$\begin{aligned} P_d &= \frac{RPI_a}{RPI_0} \left[ \frac{(\frac{C}{2})(1 + \tau)^{\frac{1}{2}}}{(1 + \frac{1}{2}ri)} + \frac{(\frac{C}{2})(1 + \tau)}{(1 + \frac{1}{2}ri)^2} + \dots + \frac{(\{\frac{C}{2}\} + M)(1 + \tau)^{\frac{N}{2}}}{(1 + \frac{1}{2}ri)^N} \right] \\ &= \frac{RPI_a}{RPI_0} \left[ \frac{(\frac{C}{2})}{(1 + \frac{1}{2}ry)} + \dots + \frac{(\frac{C}{2}) + M}{(1 + \frac{1}{2}ry)^N} \right] \end{aligned} \quad (4.16)$$

where

$$RPI_a = \frac{RPI_1}{(1 + \tau)^{\frac{1}{2}}}$$

$RPI_0$  is the base index level as initially described.  $RPI_a/RPI_0$  is the rate of inflation between the bond's issue date and the date the yield calculation is carried out.

It is best to think of the equations for money yield and real yield by thinking of which discount rate to employ when calculating a redemption yield for an indexed bond. Equation (4.13) can be viewed as showing that the money yield is the appropriate discount rate for discounting money or nominal cash flows. We then re-arrange this equation as given in (4.16) to show that the real yield is the appropriate discount rate to use when discounting real cash flows.

### **Assessing yield for index-linked bonds**

Index-linked bonds do not offer *complete* protection against a fall in the real value of an investment. That is, the return from index-linked bonds including I-L gilts is not in reality a guaranteed real return, in spite of the cash flows being linked to a price index such as the RPI. The reason for this is the lag in indexation, which for I-L gilts is eight months. The time lag means that an indexed bond is not protected against inflation for the last interest period of its life, which for gilts is the last six months. Any inflation occurring during this final interest period will not be reflected in the bond's cash flows and will reduce the real value of the redemption payment and hence the real yield. This can be a worry for investors in high inflation environments. The only way to effectively eliminate inflation risk for bondholders is to reduce the time lag in indexation of payments to something like one or two months.

Bond analysts frequently compare the yields on index-linked bonds with those on conventional bonds, as this implies the market's expectation of inflation rates. To compare returns between index-linked bonds and conventional bonds analysts calculate the *break-even inflation rate*. This is the inflation rate that makes the money yield on an index-linked bond equal to the redemption yield on a conventional bond of the same maturity. Roughly speaking the difference between the yield on an indexed bond and a conventional bond of the same maturity is what the market expects inflation during the life of the bond to be; part of the higher yield available on the conventional bond is therefore the inflation *premium*. In August 1999 the redemption yield on the 5¾% Treasury 2009, the 10-year benchmark gilt, was 5.17%. The real yield on the 2½% index-linked 2009 gilt, assuming a constant inflation rate of 3%, was 2.23%. Using (4.13) this gives us an implied break-even inflation rate of:

$$\begin{aligned}\tau &= \left\{ \frac{[1 + \frac{1}{2}(0.0517)]}{[1 + \frac{1}{2}(0.0223)]} \right\}^2 - 1 \\ &= 0.029287 \text{ or } 2.9\%\end{aligned}$$

If we accept that an advanced, highly developed and liquid market such as the gilt market is of at least semi-strong form, if not strong form, then the inflation expectation in the market is built into these gilt yields. However if this implied inflation rate understated what was expected by certain market participants, investors will start holding more of the index-linked bond rather than the conventional bond. This activity will then force the indexed yield down (or the conventional yield up). If investors had the opposite view and thought that the implied inflation rate overstated inflation expectations, they would hold the conventional bond. In our illustration above, the market is expecting long-term inflation to be at around 2.9% or less, and the higher yield of the 5¾% 2009 bond reflects this inflation expectation. A fund manager will take into account their view of inflation, amongst other factors, in deciding how much of the I-L gilt to hold compared to the conventional gilt. It is often the case that investment managers hold indexed bonds in a portfolio against specific index-linked liabilities, such as pension contracts that increase their payouts in line with inflation each year.

The premium on the yield of the conventional bond over that of the index-linked bond is therefore compensation against inflation to investors holding it. Bondholders will choose to hold index-linked bonds instead of conventional bonds if they are worried by unexpected inflation. An individual's view on expected inflation will depend on several factors, including the current macro-economic environment and the credibility of the monetary authorities, be they the central bank or the government. In certain countries such as the UK and New Zealand, the central bank has explicit inflation targets and investors may feel that over the long term these targets will be met. If the track record of the monetary authorities is proven, investors may feel further that inflation is no longer a significant issue. In these situations the case for holding index-linked bonds is weakened.

The real yield level on indexed bonds in other markets is also a factor. As capital markets around the world have become closely integrated in the last twenty years, global capital mobility means that high inflation markets are shunned by investors. Therefore over time expected returns, certainly in developed and liquid markets, should be roughly equal, so that real yields are at similar levels around the world. If we accept this premise, we would then expect the real yield on index-linked bonds to be at approximately similar levels,

whatever market they are traded in. For example we would expect indexed bonds in the UK to be at a level near to that in say, the US market. In fact in May 1999 long-dated I-L gilts traded at just over 2% real yield, while long-dated indexed bonds in the US were at the higher real yield level of 3.8%. This was viewed by analysts as reflecting that international capital was not as mobile as had previously been thought, and that productivity gains and technological progress in the US economy had boosted demand for capital there to such an extent that real yield had had to rise. However, there is no doubt that there is considerable information content in index-linked bonds and analysts are always interested in the yield levels of these bonds compared to conventional bonds.

## Appendix 4.2: The UK Retail Prices Index

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
January	78.73	82.61	86.84	91.2	96.25	100	103.3	111.0	119.5	130.2	135.6	137.9	141.3	146.0	150.2	154.4	159.5	163.4
February	78.76	82.97	87.2	91.94	96.6	100.4	103.7	111.8	120.2	130.9	136.3	138.8	142.1	146.9	150.9	155.0	160.3	163.7
March	79.44	83.12	87.48	92.8	96.73	100.6	104.1	112.3	121.4	131.4	136.7	139.3	142.5	147.5	151.5	155.4	160.8	164.1
April	81.04	84.28	88.64	94.78	97.67	101.8	105.8	114.3	125.1	133.1	138.8	140.6	144.2	149.0	152.6	156.3	162.6	165.2
May	81.62	84.64	88.97	95.21	97.85	101.9	106.2	115.0	126.2	133.5	139.3	141.1	144.7	149.6	152.9	156.9	163.5	165.6
June	81.85	84.84	89.2	95.41	97.79	101.9	106.6	115.4	126.7	134.1	139.3	141.0	144.7	149.8	153.0	157.5	163.4	165.6
July	81.88	85.3	89.1	95.23	97.52	101.8	106.7	115.5	126.8	133.8	138.8	140.7	144.0	149.1	152.4	157.5	163.0	165.1
August	81.9	85.68	89.94	95.49	97.82	102.1	107.9	115.8	128.1	134.1	138.9	141.3	144.7	149.9	153.1	158.5	163.7	165.5
September	81.85	86.06	90.11	95.44	98.3	102.4	108.4	116.6	129.3	134.6	139.4	141.9	145.0	150.6	153.8	159.3	164.4	166.2
October	82.86	86.36	90.67	95.59	98.45	102.9	109.5	117.5	130.3	135.1	139.9	141.8	145.2	149.8	153.8	159.5	163.5	
November	82.66	86.67	90.95	95.92	99.29	103.4	110.0	118.5	130.0	135.6	139.7	141.6	145.3	149.8	153.9	159.6	164.4	
December	82.51	86.89	90.87	96.05	99.62	103.3	110.3	118.8	129.9	135.7	139.2	141.9	146.0	150.7	154.4	160.0	164.4	

**Table 4.2:** United Kingdom Retail Price Index. (Source: ONS).

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No paper changed hands until the contract note was completed at the end of the day . . . the expression “My word is my bond” was essential to the functioning of the [stock exchange] floor.

– Philip Augar, *The Death of Gentlemanly Capitalism* 2000

# 5 The Gilt-Edged Market III: The Gilt Strips Market

## 5.1 Gilt strips

The introduction of gilt strips was part of a range of measures developed by the Bank of England (BoE) and HM Treasury in connection with the modernisation and reform of the gilt market. An official market in zero-coupon government bonds had previously been available in the United States from 1985 and France from 1991; among developed economies, strips markets now exist in Canada, Germany, Italy, Spain, Holland, Belgium and New Zealand.

### 5.1.1 *Market mechanics*

A strip is a zero-coupon bond, that is a bond that makes no coupon payments during its life and has only one cash flow, its redemption payment on maturity. “Stripping” a bond is the process of separating a standard coupon bond into its individual coupon and principal payments, which are then separately held and traded in their own right as zero-coupon bonds. For example a ten-year gilt can be stripped into 21 zero-coupon bonds, comprising one bond from the principal repayment and twenty from the semi-annual coupons. Coupon payments due in six, twelve, eighteen and so on months from the stripping date would become six, twelve, eighteen and so on month zero-coupon bonds. The prices of such bonds are related to the yield curve derived from conventional bonds. If a yield curve is upward sloping (positive), the theoretical zero-coupon yield curve will lie above the conventional bond yield curve, while if the conventional curve is inverted, the zero-coupon curve will lie below it.

The gilt strips market is a recent development, with trading having commenced only on 8 December 1997. Not all gilts are strippable; only stocks designated as being strippable by the BoE (and subsequently the DMO) may be stripped. The market began quietly with relatively low volumes of trading. After one month’s trading, under 1% of the (then) £82 billion of strippable stock was held in stripped form. In this time turnover in the strips market, for both coupon and principal strips, amounted to 1% of turnover in the conventional gilt market (BoE, *Quarterly Bulletin*, Feb 1998).



Gilts held in Crest can be stripped or reconstituted by gilt-edged market makers (GEMMs). Strips are fully fledged gilts; they remain registered securities and liabilities of HM Government, therefore they have identical credit risk compared to conventional gilts. The minimum strippable amount for all gilts is £10,000 nominal. This can then be increased in units of £10,000 nominal. There is no limit on the amount or proportion of a strippable gilt issue that can be stripped or reconstituted. The Crest system, inherited from CGO, includes a forward input facility for stripping and reconstitution requests to be entered up to one month in advance. GEMMs will include strips trading as part of their general gilt market-making obligations.

We have noted that strips are fully-fledged gilts, registered securities and liabilities of the government. They are stripped and reconstituted via the Crest facility, on the direction of GEMMs. It is not possible to remove a strip from Crest and hold it in paper form. Although any investor can hold and trade strips, they are not available via the BoE's Brokerage Service, the facility that allows private investors to buy and sell conventional gilts through the Post Office. Private investors must buy and sell gilts through a stockbroker. This is because when strips were introduced, the BoE believed that strips, which carried greater interest-rate risk than conventional gilts of similar maturity, should not be available for purchase by retail investors unless they were aware of their characteristics; therefore strips cannot be purchased through the post.

Stripped coupons from different gilts but with the same coupon dates are fully fungible; this increases their liquidity. At the moment there is no fungibility between coupon and principal strips, although this remains under review and may be possible at a later date. Strippable gilts have two sets of coupon dates, 7 June and 7 December or 7 March and 7 September each year, so that all strips mature on these dates each year. Strips are not deliverable into the LIFFE medium and long-gilt futures contracts; for these it is necessary to deliver a coupon gilt from amongst those in the futures contract delivery basket.

### **5.1.2 *Strippable gilts***

At the end of December 1999 there were 36 conventional gilts in issue, excluding rump status gilts, of which 11 were strippable. Table 5.1 is a list of the strippable gilts and the amount held in stripped form as at the end of June 2002; for comparison we also show the amount held in stripped form at the end of March 2001. At the beginning of June 2002 the total nominal amount of strippable stock was £116.2 billion, of which £2.82 billion was held in stripped form, representing 2.42% by volume.

Table 5.1 shows that the amount of gilts held in stripped form stayed in the range of 1% to 2% of total nominal value during 2001 to June 2002. At the start of the market in 1998 and 1999 the volume of gilts held as strips was at around 2.0% to 2.5%. The BoE stated before the start of the strips market that all new benchmark issues will now be eligible for stripping. Initially all strippable stocks had the same coupon dates (7 June and 7 December), which allowed all coupon strips to be fungible. Now with the issue of the 5% Treasury 2012 in May 2001, which has coupon dates of 7 March and 7 September, coupon strips with these coupon dates are also available. The DMO has left open the possibility of making coupon and principal strips fungible, and whether to introduce a second set of coupon dates. There is no limit on the amount or proportion of any strippable gilt that can be stripped.

A complete table of strip prices and yields as at March 1999 is given in Appendix 5.1.

Stock	Redemption date	Amount in	Amount held	Strips as %	Amount in	Amount
		issue (£m)	in stripped form (£m)	of issue	issue (£m)	held in stripped form (£m)
		28 June 2002	28 June 2002	28 June 2002	30 Mar 2001	30 Mar 2001
7% Treasury 2002	07-Jun-02	–	–	–	9,000	232
6½% Treasury 2003	07-Dec-03	8,095	42	0.52	7,987	94
5% Treasury 2004	07-Jun-04	7,504	7	0.09	7,408	113
8½% Treasury 2005	07-Dec-05	10,486	142	0.14	10,373	327
7½% Treasury 2006	07-Dec-06	11,807	215	1.82	11,700	265
7¼% Treasury 2007	07-Dec-07	11,103	113	1.02	11,000	242
5¾% Treasury 2009	07-Dec-09	8,937	22	0.25	8,827	165
5% Treasury 2012	07-Mar-12	13,346	0	0.00	–	–
8% Treasury 2015	07-Dec-15	7,377	334	4.53	7,288	357
8% Treasury 2021	07-Jun-21	16,741	294	1.76	16,500	353
5% Treasury 2025	07-Mar-25	7,672	0	0.00	–	–
6% Treasury 2028*	07-Dec-28	11,756	122	1.04	11,500	161
4¼% Treasury 2032	07-Jun-32	13,829	82	0.59	13,580	25

\*6% Treasury 2028 eligible for stripping following auction on 20 May 1998, which took amount in issue to £5 billion.

**Table 5.1:** List of strippable stocks and amount stripped as at June 2002.  
(Source: DMO).

### 5.1.3 Pricing convention

The BoE consulted with GEMMs before the introduction of the strips market on the preferred method for pricing strips. The result of this consultation was announced in May 1997 when the Bank stated that strips would trade on a yield basis rather than a price basis. The day count convention adopted, in both the conventional and strips market, was actual/actual; this was changed from the previous method of actual/365 on 1 November 1997. Those GEMMs who had preferred to quote strips on a price basis had claimed that there may have been difficulties with agreeing a standard formula for converting yields into prices. The yield pricing convention is in line with other zero-coupon bond markets in Europe and North America.

After further consultation the following standard formula was adopted for use in the market:

$$P = \frac{100}{\left(1 + \left(\frac{r}{s}\right)^{\frac{d}{s} + n}\right)} \quad (5.1)$$

where

- $P$  is the price per £100 nominal of the strip
- $r$  is the gross redemption yield (decimal)
- $d$  is the exact number of days from the settlement date to the next quasi-coupon date
- $s$  is the exact number of days in the quasi-coupon period in which the settlement date falls
- $n$  is the number of remaining quasi-coupon periods after the current period.

The  $r$  and  $s$  values are not adjusted for non-working days. A *quasi-coupon* date is a date on which a coupon would be due if the bond was a conventional coupon bond rather than a strip. For example a strip maturing on 7 December 2005 would have quasi-coupon dates of 7 June and 7 December each year until maturity. A *quasi-coupon period* is defined to be the period between consecutive quasi-coupon dates. There are always six calendar months, regardless of the nature of the first coupon. For example a gilt settling on its issue date (assuming this is not also a quasi-coupon date) will have a quasi-coupon period which starts on the quasi-coupon date prior to the issue date and ends on the first quasi-coupon date following the issue date.

This method is also used in the US strips market, and is sometimes referred to as the US “street” convention. The formula uses simple interest for the shortest strip, which is consistent with money market convention, and compound interest for all other strips which is then consistent with gilt market convention. The shortest strip is discounted on an actual/actual basis, which is inconsistent with sterling money market convention but is consistent with the convention followed in the gilt market. All other strips are discounted on an actual/actual basis. Using this method results in a jump in price when the shortest-but-one strip becomes the shortest since the formula switches from discounting on a compound interest basis to a simple interest basis.

Expression (5.1) is also used for strips with only one quasi-coupon period remaining.

Yields are quoted to three decimal places; cash prices are calculated to six decimal places. The rounding convention is to round the third decimal place up by one if the fourth (or seventh) decimal place is 5 or above, and then to shorten at the third decimal place.

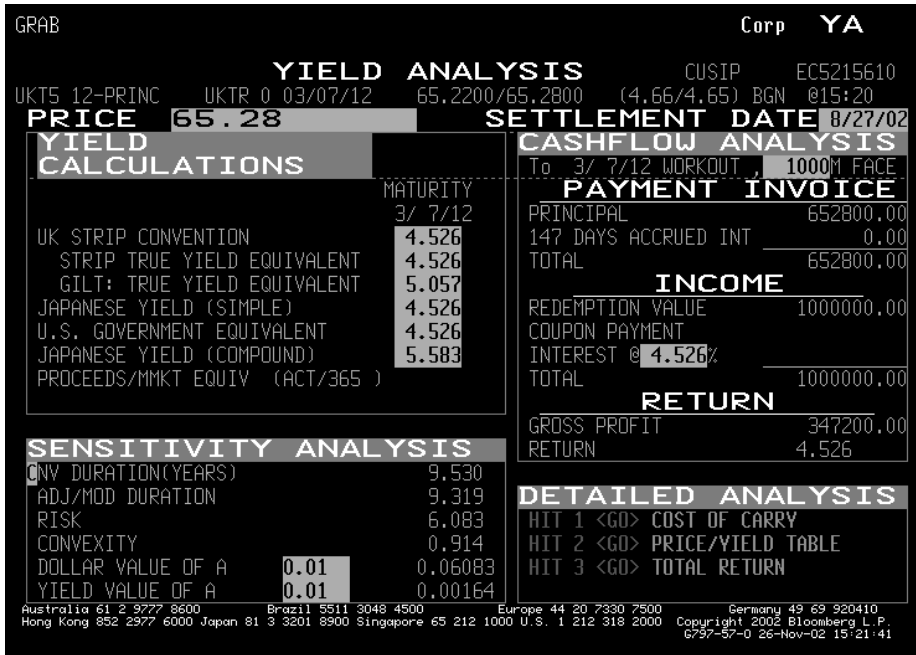
Figure 5.1 (a) and (b) show the Bloomberg pages YA and YAS for the 5% Treasury 2012 principal strip, for analysis in August 2002. The page for the conventional gilt itself is shown at Figure 5.2.

#### 5.1.4 Interest rate risk for strips

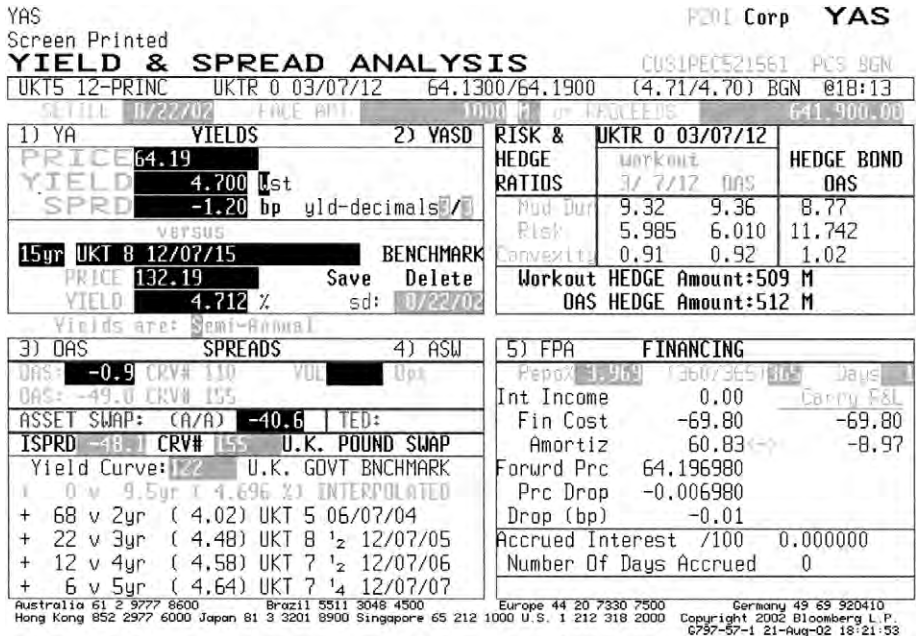
Strips have a longer duration than equivalent maturity conventional bonds. As they are zero-coupon bonds their duration is equal in time to their maturity. The duration of a strip will decline roughly in parallel with time, whereas for a conventional bond the decline will be less. For a given modified duration, a strip will be less convex than a coupon bond. The following points highlight some of the salient points about how duration and convexity of strips compare with those of coupon bonds:

- strips have a Macaulay duration equal to their time in years to maturity;
- strips have a higher duration than coupon bonds of the same maturity;
- strips are *more* convex than coupon bonds of the same maturity;
- strips are *less* convex than coupon bonds of the same duration.

The reason that a strip is less convex than a conventional coupon bond of the same duration is that the coupon bond will have more dispersed cash flows than the strip. Although strips are less convex than bonds of identical duration, the highest duration conventional gilt (6% Treasury 2028) had a duration of 15.56 years (modified duration 15.26) in March 1999, whereas the principal strip from that bond had a duration of 29.77 years at that time (modified duration 29.14). Long strips are therefore the most convex instruments in the gilt market.



(a)



(b)

Figure 5.1 (a) and (b): Yield analysis/yield and spread analysis for principal strip created from 5% Treasury 2012 gilt, August 2002. © Bloomberg L.P. Used with permission.

YIELD CALCULATIONS		CASHFLOW ANALYSIS	
TRUE / D.M.O. YIELD	4.624	4.624	PRINCIPAL
CONSORTIUM YIELD	4.624	4.624	173 DAYS ACCRUED INT
U.S. GOVT EQUIVALENT	4.624	4.624	TOTAL (W/TRNCH)
EQUIVALENT 1/YEAR COMPOUND	4.677	4.677	<b>INCOME</b>
TRUE YIELD	4.624	4.624	REDEMPTION VALUE
DEBT MANAGEMENT OFFICE YIELD	4.624	4.624	COUPON PAYMENT
PROCEEDS/MMKT EQUIVALENT			INTEREST @ 4.615%
After Tax Inc 23.00% CG	3.493	3.493	TOTAL
NEXT NEGATIVE AI DATE	8/30/02	( 8 DAYS)	<b>RETURN</b>
Bond is Cum-Dividend at Settlement			GROSS PROFIT
<b>SENSITIVITY ANALYSIS</b>			RETURN
DNV DURATION (YEARS)	7.554	7.554	
ADJ/MOD DURATION	7.383	7.383	
RISK	7.769	7.769	
CONVEXITY	0.671	0.671	
PRICE VALUE OF A	0.01	0.07769	
YIELD VALUE OF A	0.01	0.00129	
<b>DETAILED ANALYSIS</b>			
HIT 1 <GO> TOTAL RETURN			
HIT 2 <GO> PRICE TABLE			

Australia 61 2 9277 8600    Brazil 5511 3048 4500    Europe 44 20 7330 7500    Germany 49 69 920410  
 Hong Kong 852 2977 6000    Japan 81 3 3201 8900    Singapore 65 212 1000    U.S. 1 212 318 2000    Copyright 2002 Bloomberg L.P.  
 6797-57-0 26-Nov-02 15:19:53

Figure 5.2: Yield analysis for 5% Treasury 2012 conventional gilt, August 2002.

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### 5.1.5 Uses of strips

Strips are a new instrument in the sterling bond markets. They have a large number of uses for investors and traders. The following properties of strips make them potential attractive investments for market participants:

- simplicity of one cash flow at maturity allows matching to future liabilities;
- more precise management of cash flows;
- no reinvestment risk, as associated with conventional coupon-bearing bonds;
- holdings can be tailored to portfolio sensitivities;
- higher duration and convexity than conventional bonds of the same maturity, which would be useful for either duration weighting a portfolio or for taking risk positions;
- tax advantages in certain jurisdictions.

Strips are arguably the most basic cash flow structure available in the capital markets, being as they are zero-coupon paper. By investing in a portfolio of strips an investor is able to construct a desired pattern of cash flows, one that matches more precisely his investment requirements than that obtained from a conventional bond. In theory therefore there is a high demand for strips in the market. Domestic institutional investors with an interest at the long end of the yield curve will have a demand for long-dated strips, for example, life assurance

companies and pension funds who have liabilities up to 30 years or more into the future. While strips can help to meet this demand, due to their providing a known amount at the end of a long-dated investment horizon, they are also attractive in that they present no reinvestment risk. The rate of return gained from buying a strip today and holding to maturity will be a true yield.

Retail investors and their advisers are also interested in strips because they allow them to have investments with cash flows of their choice. Where private investors wish to invest for a known future commitment, they can also hold strips and realise the precise amount required at their investment horizon.

We can summarise the main uses of strips as follows:

- matching long liabilities (pension funds);
- matching cash flows (insurance companies wishing to match their actuary-estimated payments, interested in acquiring forward-starting annuities);
- collateralisation of guarantees (financial companies, for example firms selling products with a guaranteed return, such as a guaranteed equity fund or guaranteed minimum return stock-market linked savings, ISA or other account);
- expressing views on sterling interest rates (commercial and investment banks, foreign investors and money market funds);
- taking advantage of the high duration of strips (hedge funds, proprietary traders).

It is possible to lend and repo strips, as with conventional gilts, and therefore also “short” strips that one does not own and cover such short positions via borrowing or reverse repo. Because of certain properties of strips, namely their longer duration making them more price volatile, certain market participants may prefer not to deal in strips repo. However as the gilt repo market includes provision for initial margin and (if required by a participant) daily margin, this should not make strips unattractive as repo collateral. The repo of gilt strips is carried out in exactly the same way as with conventional gilts, with the exception that there is no accrued interest to consider when calculating settlement amounts.

The BoE announced in April 1998 that strips would be eligible in Delivery-by-Value (DBV) collateral in its daily money market operations. Therefore strips have from that date been eligible for use in daily repo operations with the Bank.

### **5.1.6 *Subsequent developments and analysis of market volumes***

Since the start of trading in gilt strips, activity has remained low and has built up only gradually. The introduction of the new 30-year benchmark gilt, the 6% Treasury 2028 added a new potentially attractive investment instrument to the market. Although this stock was first auctioned in January 1998 it was not made strippable until May that year, when the total volume outstanding was raised to £5 billion; it was felt by the BoE that the initial amount of £2 billion was not large enough to provide sufficient liquidity. At April 1998 the percentage of strippable stock held in stripped form stood at 2.2% (BoE, QB, May 1998). Turnover remained low in the first four months of trading, at an average of £135 million per week. At the time this figure represented 1/2% of turnover in the conventional gilt market (*ibid*). The BoE observed that a large proportion of activity involved overseas investors taking a view on sterling and exploiting arbitrage opportunities that existed between the gilt strips market and strips markets in Germany and France. The main customer interest in the early months of trading appeared to be in principal strips at the longer end of the curve,

while GEMM activity would appear to be concentrated on trading principal strips against the underlying coupon gilt. This last activity is to be expected, and is the main reason that strips trading originally began in the US market. The profit potential for a government bond market maker who strips a coupon bond is mainly found in any arbitrage opportunity that results from mispricing of the underlying bond or the strip.

There are several reasons behind the slow build-up to trading in strips. A BoE analysis (QB, Feb 1999) has suggested that these reasons include the following:

- because strips are not yet included in any industry benchmarks, there is no particular incentive for fund managers to buy and hold them (and no pressure from actuaries). An “index tracker” bond fund is more likely to buy the conventional long-dated bond;
- when the benchmark yield curve is negatively sloping, strip yields will lie below coupon bond yields. As the gilt yield curve has been inverted since before the start of trading in strips, strips have traded at yields below the conventional curve, making them look expensive relative to coupon bonds. As strips are zero-coupon instruments their duration will be longer than those of coupon gilts of the same maturity. In this environment therefore, strip yields will be closer to yields of longer-dated coupon gilts, compared to the yield on similar maturity gilts. The shape of the strips yield curve will deter some investors from holding strips because they would view them as dear to the coupon bond curve;
- as client interest in strips has remained low, activity in the professional market (between GEMMs) has also been low; lower liquidity has resulted in less competitive price quotes from GEMMs, which has increased further the cost of buying strips;
- to date the repo market in strips has been limited, which would make the financing of strips positions comparatively more costly. This may turn into something of a vicious circle, as low liquidity in strips will lead to low volumes in strips repo, which will further make the running of strips portfolios less economically attractive. Strips market repo activity should be helped through the BoE’s incorporation of strips in its daily money market operation, which made strips eligible for use as collateral via DBV. Strips have been so eligible since April 1998. However strips generally always trade as *special* in the repo and stock loan markets, and coupon strips are very illiquid in these markets.

Private retail investment in strips has been low as a result of the tax treatment for strips, whereby the bonds are taxed annually on any capital gain made, even though no income has been received in the taxation period. The introduction of a new product for retail investors, the Individual Savings Account, which allows tax-free investment in strips (among other securities), should make them more attractive for private investment.

As the market in strips becomes more mature and as more investors become familiar with the instrument, we can expect to see trading volumes increase. In theory interest in trading and holding strips should increase if at any point the yield curve flattens out or becomes positively sloped. In July 1999 the gilt yield curve changed to a positive sloping shape from the two to seven years’ maturity range,<sup>1</sup> so analysis of strips volumes in the year following this

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<sup>1</sup> Although this was short-lived, with the curve reverting to negatively sloping after the 3-year maturity area shortly after.

period should indicate higher levels of trading. In any case the introduction of strips has added a flexible new investment product that should benefit sterling markets generally.

## 5.2 Zero-coupon bond trading and strategy

As we have noted elsewhere trading in strips began only gradually, and volume and liquidity levels are expected to increase as the market becomes more mature. At the start of trading, transparency in the market was not as high as that in the coupon gilt market, a factor that some GEMMs were able to exploit to their advantage. That said, strips are familiar to participants in other markets such as the USA and France, and the principles of strips trading are generally the same across markets. We present here some basic concepts and strategies that are common in strips markets.

### 5.2.1 Strips versus coupon bonds

Before looking at trading strategies let us reiterate what was said earlier on the properties of strips. The main characteristics of strips are:

- they have a Macaulay duration equal to their maturity;
- they have no reinvestment risk because there are no intermediate cash flows;
- their prices and yields are relatively easy to calculate and require no iteration.

In theory, stripping and reconstituting a bond would be attractive if the sum value of each of the components (coupon and principal strips) is greater or less than the value of the underlying bond. Where this occurs, arbitrage profits are possible. However, the market mechanism will ensure that this (almost) never happens, hence strips market participants in the UK are able to deal in an efficient and fairly priced environment.

The higher duration of strips gives them greater leverage. A smaller cash investment is required to buy a certain nominal amount compared to bonds. As strips have a much higher duration for the same calendar maturity, they offer greater flexibility in matching specific cash flows. The higher convexity of strips is also an attractive feature, as convexity in a bond is a desired property. It means that the bond will appreciate more in price for a given decline in yield, than it will depreciate for the same back-up in yield. Table 5.2 is a convexity example from the German bund strips market.

Strips offer the opportunity to create strategies for a given duration with higher convexity than the equivalent coupon bond, which means strips can benefit from market volatility. This is shown in Table 5.2.

Yield = 5.47%	Modified duration	Convexity	% price change – 100 bp yield	% price change + 100 bp yield
Bund:				
6.25% 2024	11.2	2.4	13.9	–11.5
Principal Strip 2024	24.9	6.4	28.4	–22.0
Coupon Strip 2010	11.2	1.6	13.1	–11.5

**Table 5.2:** Bund market strips example. (Data source: Bloomberg).



There is a further potential attraction in that strips can reduce currency exposure for non-sterling based investors. The increased duration and lower price (in a positive sloping yield curve environment) of a strip relative to a similar maturity coupon gilt means that an investor can buy a smaller nominal amount of zero-coupon bonds and still maintain their desired interest rate exposure.

### 5.2.2 Determining strip value

It is always important to understand how strips behave under different yield curve conditions and over time; this will help the investor to identify relative value. We have already shown that the yield on a strip is predominantly a function of the shape of the yield curve, as well as related factors such as supply and demand, liquidity, market sentiment, future interest rate expectations and tax issues.

The three most common ways to calculate the value of a strip are:

- valuation using the bond curve;
- equivalent duration method;
- theoretical zero-coupon curve construction.

#### Valuation using the bond curve

The spread between a strip and a bond with the same maturity is often used as an indicator of strip value. It is essentially a rough-and-ready approach; its main drawback is that two instruments with different risk profiles are being compared against each other. This is particularly true for longer maturities.

#### Equivalent duration method

When measuring relative value, aligning the strip and coupon bond yields on the basis of modified duration will allow for a better comparison. From Figure 5.3 it would appear that

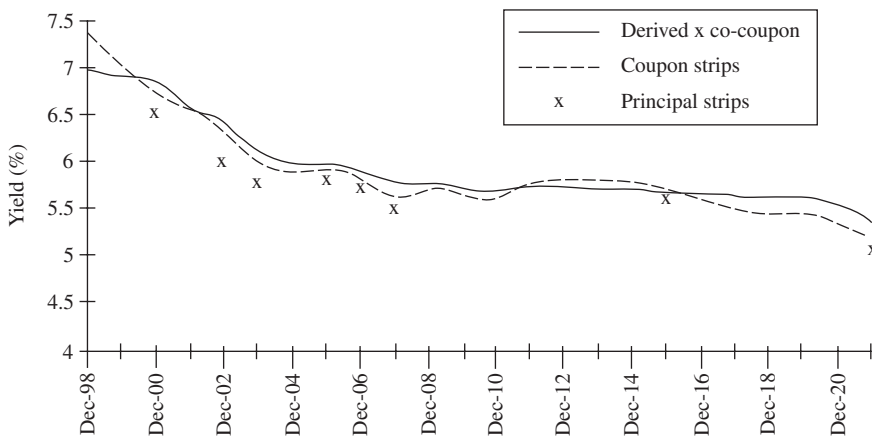


Figure 5.3: Strip yield curves January 1998. (Source: Bloomberg, DMO).

at this time coupon strips are cheap at the short end and particularly expensive at the longer end. A proper analysis will require us to construct a curve of yields against modified duration, and check for value on such a curve. However, we would have no indication as to how strip values will change for various yield curve moves.

### ***Theoretical zero-coupon curve***

This is the most common way of determining the value of a strip, via the derivation of a theoretical zero-coupon curve. The actual strip yield curve can differ from a spot curve derived from the benchmark yield curve. When such anomalies occur there may be an opportunity for profitable relative value trading. For example, a trader may wish to examine the shapes of the theoretical and actual zero-coupon curves and where they have differed from each other over time. A spread trade can be put on where an anomaly is detected, for instance where there is a greater than usual divergence of an actual yield from a theoretical yield. When the curves converge again the spread is unwound and the trader takes their profit.

A theoretical spot curve is usually calculated from a theoretical bond par yield curve (the par curve is often constructed by plotting the existing bond yields against their respective maturities, and then fitting a curve through these points using predetermined criteria). We examined in the forward rates case study how the zero-coupon or spot yield curve is then derived from a coupon curve. Strips will often trade at a spread to the theoretical zero-coupon bond value; this indicates which maturities are cheap and which expensive. And as we noted just now, in this way anomalies can be identified. In the gilt strips market, the zero-coupon curve tends to be well arbitrated on forward rates. This means that while there may well appear to be arbitrage opportunities available when analysing the spot yield curve, special repo conditions will make actual arbitrage almost impossible. This is usually taken into account in the shape of the forward curve.

### ***5.2.3 Slope of the yield curve***

When the curve is flat, the spot curve will also be flat. When the yield curve is negative, the theoretical zero-coupon curve must lie below the coupon yield curve. This is because the yield on coupon-bearing bonds is affected by the fact that the investor receives part of the cash flow before the maturity of the bond; the discount rates corresponding to these earlier payment dates are higher than the discount rate corresponding to the final payment date on redemption. In addition the spread between zero-coupon yields and bond yields should increase negatively with maturity, so that zero-coupon bonds always yield less than coupon bonds.

In a positively shaped yield curve environment, the opposite is true. The theoretical zero-coupon curve will lie above the coupon curve. It is interesting, however, to observe the overall steepness of the curves. In general the steeper the coupon curve, the steeper the zero-coupon curve will be. It should be remembered that each yearly value of the coupon curve is considered in the derivation of the zero-coupon curve. Hence a yield curve could for example, have exactly 1-year, 10-year and 30-year yields, while the theoretical zero-coupon 30-year yield could be substantially higher or lower. The derived yield level would depend on whether the points on the term structure in between these maturity bands were connected by a smooth curve or straight line. This argument is sometimes cited as a reason

for not using the bootstrapping method, in that the theoretical zero-coupon yields that are obtained are too sensitive for real-world trading. Bond analysts often use sophisticated curve smoothing techniques to get around this problem, and produce theoretical values that are more realistic. This issue becomes more important when there are few bonds between points on the term structure, such that linear interpolation between them produces inaccurate results. For example between the ten-year and thirty-year maturities there are eight liquid gilts; between twenty and thirty years there are only two gilts. This is a key reason for analysts to use more sophisticated curve-fitting techniques.

### 5.3 Strips market anomalies

From the start of gilt strips trading the market has observed some long-standing anomalies that mirror observations from other strips markets, such as those in the USA and France. These include the following:

#### *Final principal trades expensive*

It might be expected that the strip yield curve should behave in a similar fashion to the coupon curve. However, due to supply and demand considerations more weight is always given to the final principal strip, and this is indeed so in the gilt strips market.

#### *Longest maturity is the most expensive*

A characteristic seen in all well-developed strip markets is that maturities with the longest duration and the greatest convexity trade expensive relative to theoretical values. Conversely, intermediate maturities tend to trade cheap to the curve. This can be observed when looking at the gilt strips and coupon curves.

#### *Principal strips trade at a premium over coupon strips*

Principal strips reflect the premium investors are prepared to pay for greater liquidity and, in some markets, regulatory and tax reasons. This rule is so well established that principal strips will sometimes trade more expensive relative to coupon strips even when their outstanding nominal amount is lower than that of coupon strips.

#### *Intermediate maturity coupons are often relatively cheap*

Market makers in the past have often found themselves with large quantities of intermediate maturity coupon strips, the residue of client demand for longer maturities. This has occurred with gilt strips where at certain times coupon strips of 3–8 years' maturity have traded cheap to the curve.

#### *Very short coupon strips trade expensive*

In a positively sloped yield curve environment short strips are often in demand because they provide an attractive opportunity to match liabilities without reinvestment risk, at a higher yield than coupon bonds of the same maturity. We have not observed this in the gilt strips market to date, as the yield curve has been inverted from before the start of trading. However, in France for example the short end up to three years is often well bid.

## 5.4 Trading strategy

### 5.4.1 Bond replication through strips

This is the theoretical strategy and the one that presents itself first. The profit potential for a GEMM who strips a gilt lies in arbitrage resulting from a mispricing of the coupon bond. Due to the market mechanism requiring that there be no arbitrage opportunity, the bid price of a gilt must be lower than the offer price of a synthetic gilt (a gilt reconstituted from a bundle of coupon and principal strips); equally the offer price of the gilt must be higher than the bid price of a synthetic gilt. Of course if the above conditions are not satisfied, a risk-free profit can be obtained by trading the opposite way in both instruments simultaneously and earning the difference between the two prices.

The potential profit in stripping a gilt will depend on actual gilt yields prevailing in the market and the theoretical spot rate yield curve. To illustrate how a GEMM might realise a profit from a coupon stripping exercise, consider a hypothetical 5-year, 8% gilt selling at par (and therefore offering a yield to maturity of 8%), trading in a market that consists of the set of gilts shown in Table 5.3.

Assume a settlement date of 1 March 1999, which is one of our coupon dates, so that each of the bonds has precisely 0.5, 1, 1.5 and so on years to maturity. The prices and gross redemption yields of our gilts are stated for each bond. Using these yields and prices we can compute the theoretical or *implied* zero-coupon (spot) interest rates for each period. This is shown in Table 5.4. Let us imagine that the GEMM buys the gilt at par and strips it, with the intention of selling the resulting zero-coupon bonds at the yields indicated for the corresponding maturity shown in Table 5.4. The theoretical spot rates shown have been calculated using the coupon yields and the *bootstrapping* method.

The gross redemption and spot yield curves for the set of hypothetical gilts are shown in Figure 5.4.

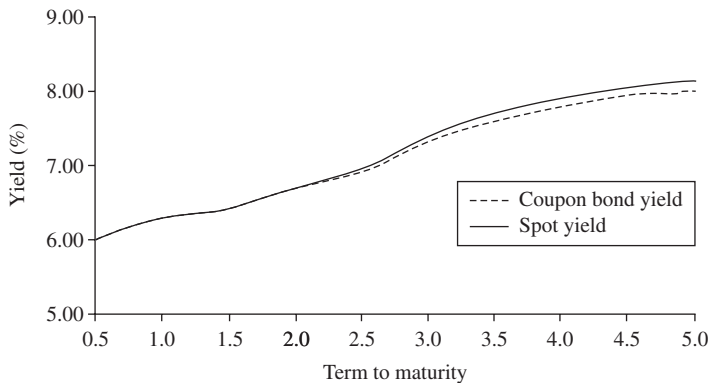
Table 5.5 shows the price that the GEMM would receive for each strip that was created from the 8% five-year gilt. The price of a coupon bond is the discounted total present value of all its cash flows using the required market interest rate. Here we can equate it to the total present value of all the cash flows from the strips, each discounted at the yield corresponding

Maturity date	Years to maturity	Coupon (%)	Yield to maturity (%)	Price (£)
1-Sep-99	0.5	0.0	6.00	97.0874
1-Mar-00	1.0	10.0	6.30	103.5322
1-Sep-00	1.5	7.0	6.40	100.8453
1-Mar-01	2.0	6.5	6.70	99.6314
1-Sep-01	2.5	8.0	6.90	102.4868
1-Mar-02	3.0	10.5	7.30	108.4838
1-Sep-02	3.5	9.0	7.60	104.2327
1-Mar-03	4.0	7.3	7.80	98.1408
1-Sep-03	4.5	7.5	7.95	98.3251
1-Mar-04	5.0	8.0	8.00	100.0000

**Table 5.3:** Hypothetical gilt prices and yields.

Maturity date	Years to maturity	Yield to maturity (%)	Theoretical spot rate (%)
1-Sep-99	0.5	6.00	6.000
1-Mar-00	1.0	6.30	6.308
1-Sep-00	1.5	6.40	6.407
1-Mar-01	2.0	6.70	6.720
1-Sep-01	2.5	6.90	6.936
1-Mar-02	3.0	7.30	7.394
1-Sep-02	3.5	7.60	7.712
1-Mar-03	4.0	7.80	7.908
1-Sep-03	4.5	7.95	8.069
1-Mar-04	5.0	8.00	8.147

**Table 5.4:** Hypothetical gilt spot yields.



**Figure 5.4:** Hypothetical gilt yield curves.

to its specific maturity (from Table 5.4). The proceeds received from selling the strips come to a total of £100.4913 per £100 of par value of the gilt originally bought by the GEMM.

We can see why the GEMM has had the opportunity to realise this profit. Consider the fourth column in Table 5.5. This shows us how much the GEMM paid for each of the cash flows by buying the entire package of cash flows, that is, by buying the bond at a yield of 8%. For instance, consider the £4 coupon payment due in three years. By buying the five-year gilt priced to yield 8%, the GEMM pays a price based on 8% (4% semi-annual) for that coupon payment, which is £3.1613. However if we accept the assumptions in this illustration, investors are willing to accept a lower yield, 7.30% (3.65% semi-annual) and purchase a strip with three years to maturity at the price marked. Note that the present value calculation uses equation (5.2) which is the standard discounted cash flow equation, adjusted for bonds paying semi-annual coupons.

$$PV = \frac{FV}{\left(1 + \left(\frac{r}{2}\right)\right)^{nm}} \quad (5.2)$$

Maturity date	Years to maturity	Cash flow	Present value at 8%	Yield to maturity (%)	Present value at yield to maturity
1-Sep-99	0.5	4	3.8462	6.00	3.8835
1-Mar-00	1.0	4	3.6982	6.30	3.7594
1-Sep-00	1.5	4	3.5560	6.40	3.6393
1-Mar-01	2.0	4	3.4192	6.70	3.5060
1-Sep-01	2.5	4	3.2877	6.90	3.3760
1-Mar-02	3.0	4	3.1613	7.30	3.2258
1-Sep-02	3.5	4	3.0397	7.60	3.0809
1-Mar-03	4.0	4	2.9228	7.80	2.9453
1-Sep-03	4.5	4	2.8103	7.95	2.8164
1-Mar-04	5.0	104	70.2587	8.00	70.2587
			100.0000		100.4913

**Table 5.5:** Theoretical profit from gilt coupon stripping.

where

- $n$  is the number of years in the term (years to maturity)
- $r$  is the bond yield to maturity
- $m$  is the number of compounding periods per year.

Thus investors here are willing to pay £3.2258. On this one coupon payment (now of course a strip versus a coupon payment) the GEMM realises a profit equal to the difference between £3.2258 and £3.1613, or £0.0645. From all the strips the total profit is £0.4913 per £100 nominal.

Let us now imagine that instead of the observed yield to maturity from Table 5.5, the yield required by investors is the same as the theoretical spot rates also shown. Table 5.6 shows that in this case the total proceeds from the sale of zero-coupon gilts would be approximately £100, which being no profit would render the exercise of stripping uneconomic. This shows that where strips prices deviate from theoretical prices, there may be profit opportunities. We have shown elsewhere that there are differences between observed strip yields and theoretical yields, indicating that there are (often very small) differences between derived prices and actual prices. Do these price differences give rise to arbitrage opportunities? Due to the efficiency and transparency of developed country bond markets, the answer is usually no. It is the process of coupon stripping that prevents the price of a gilt from trading at a price that is *materially* different from its theoretical price based on the derived spot yield curve. Also, where discrepancies arise, any arbitrage activity will cause them to disappear very quickly. As the strips market becomes more liquid, the laws of supply and demand will eliminate obvious arbitrage opportunities, as has already happened in the US Treasury market and is usually the norm in the gilts market. However, there will remain occasional opportunities to exploit differences between actual market prices of strips and the theoretical price given by the benchmark (coupon) gilt yield curve.

#### 5.4.2 Tracking theoretical spreads

Anomalies can sometimes be detected by tracking the spreads of strips against the theoretical yield curve. As noted earlier, supply and demand considerations make a strip that is

Maturity date	Years to maturity	Cash flow	Present value at 8%	Theoretical spot rate (%)	Present value at spot rate
1-Sep-99	0.5	4	3.8462	6.000	3.8835
1-Mar-00	1.0	4	3.6982	6.308	3.7591
1-Sep-00	1.5	4	3.5560	6.407	3.6390
1-Mar-01	2.0	4	3.4192	6.720	3.5047
1-Sep-01	2.5	4	3.2877	6.936	3.3731
1-Mar-02	3.0	4	3.1613	7.394	3.2171
1-Sep-02	3.5	4	3.0397	7.712	3.0693
1-Mar-03	4.0	4	2.9228	7.908	2.9331
1-Sep-03	4.5	4	2.8103	8.069	2.8020
1-Mar-04	5.0	104	70.2587	8.147	69.7641
			100.0000		~100.0000

**Table 5.6:** Theoretical versus fair value strip pricing.

not in demand trade at cheaper levels. This may induce an investor to buy the strip. Conversely a strip that is in demand will become expensive, and thus might signal a selling opportunity when compared to the average levels it has traded at historically.

### 5.4.3 Rolling down the yield curve

In a positive yield curve environment strips will give a superior return due to a greater “rolldown” effect, since the zero-coupon curve will stand higher than the par curve, especially at short maturities. On the other hand when a change in monetary policy is anticipated, switching into long duration strips will provide greater leverage and price performance.

### 5.4.4 Duration-weighted switches

It is important to ensure that the risk profile of a portfolio or position remains the same when switching from bonds into strips (assuming that the current interest rate risk exposure is what is desired). This can be achieved by duration-weighting the new portfolio made up of the strips and cash. Table 5.7 gives three hypothetical examples of duration-weighted switches for gilts and strips with assumed prices and yield values in a positive yield curve environment.

### 5.4.5 Barbell strategies

A *barbell* strategy involves selling an intermediate maturity coupon bond and using the proceeds to buy a duration-weighted combination of both shorter and longer-duration bonds. The opposite to this position is called a *butterfly*. Barbell strategies have two advantages:

- barbells increase the holding period return;
- barbells may increase the convexity of the portfolio.

	Nominal	Cash	Deposit	Yield
(1) Bond into strip: same maturity				
<b>Sell</b> Gilt 5.75% 2009	100	100	0	5.75
<b>Buy</b> Principal strip 2009	129	75	25	5.98
(2) Bond into strip: longer maturity				
<b>Sell</b> Gilt 5.75% 2009	100	100	0	5.75
<b>Buy</b> Principal strip 2021	356	59	41	7.14
(3) Bond into strip: shorter maturity				
<b>Sell</b> Gilt 5.75% 2009	100	100	0	5.75
<b>Buy</b> Coupon strip June 2002	288	262	-162	3.83
			(borrow)	

**Table 5.7:** Duration-weighted switching.

<b>Sell 26-year bond, buy 5-year bond and 25-year strip</b>			
	Cash	Mod dur	Yield
Sell 6.25% Jan 2024	1.000	12.2	6.47
Buy 6% September 2003	0.603	4.9	4.96
Buy July 2023 strip	0.397	23.4	9.27
Duration-weighted yield pick-up			14 bp

**Table 5.8:** Bund strips barbell strategy.

To achieve a possible yield pick-up in a positive yield curve environment, an investor could sell the long gilt (2028 maturity) and buy both the five-year gilt and the long strip to pick up yield while maintaining the same exposure to the market with the help of the high duration strip. However, in a negative yield curve environment, which prevailed in the gilt market at the start of trading in strips until July 1999 (and changed to being upward sloping only up to around the three-year maturity), this strategy is not possible. We have illustrated this strategy using a set of yields that existed in the German bund and strips market in July 1998, shown in Table 5.8 above.

The relative performance of the barbell is evidently subject to second-order yield curve risk. If the shape of the curve changes, the performance of the position will be affected. For example, if the yield curve steepens, that is the yield spread between the short-dated maturity and long-dated maturity widens, the barbell would benefit; if the curve flattens, the butterfly would probably outperform.

#### 5.4.6 Portfolio optimisation

Strips are attractive for cash flow matching of assets with specific liabilities, or for enhancing the portfolio yield through duration matching. This can be used both at the short and the long end of the yield curve, amongst both money market participants and longer-dated investors.



	Cash	Nominal	Mod dur	Yield
5.75% 2009	100	100	7.0	5.68
\$ cash (1 year)	50	53	0.0	6.00
Strip 2015	50	120	14.1	6.33
Weighted yield pick up				48 bp

**Table 5.9:** Cross-currency trade example.

### 5.4.7 Cross-currency spreads

The high duration characteristic of strips means that less cash is needed to invest in a market to retain the same exposure to yield moves, giving less currency exposure compared to holding coupon bonds. Table 5.9 shows a hypothetical example, in a positive yield curve environment, of a US dollar-based investor who is holding the 5 $\frac{3}{4}$ % Treasury 2009 gilt, but wishes to reduce his currency risk. By switching out of the bonds into a duration-weighted amount of 15-year strips and cash (surplus funds are deposited in short-term cash accounts), the investor has reduced his currency risk while still being able to benefit from a fall in sterling interest rates. Part of the currency risk has been exchanged for yield curve exposure.

### 5.4.8 Currency protection

During periods of high currency volatility, investors may wish to reduce their exposure to a certain currency but maintain an interest rate exposure in that currency's bond market. This can be achieved by switching from bonds into strips, and releasing the cash from this switch into assets of a currency that is perceived to be more stable. The position can be switched back when the period of currency volatility passes. The ability to take a long position in a market while limiting currency exposure will also reduce the hedging cost of the position.

## 5.5 Illustration: yield and cash flow analysis

The following examples illustrate the yield analysis and cash flows for the 5 $\frac{3}{4}$ % Treasury 2009, which matures on 7 December 2009, its principal strip and a coupon strip maturing on 7 December 2009. The 5 $\frac{3}{4}$ % 2009 was the ten-year benchmark gilt during 1999. The market information reflects the position as at February 1999, for settlement date 11 February 1999. Interest rate and price data was obtained from Bloomberg.

Table 5.10 shows the cash flows paid out to a bondholder of £1 million nominal of the 5 $\frac{3}{4}$ % 2009. On the trade date (10 February 1999, for settlement on 11 February) this bond traded at 113.15, with a corresponding yield of 4.2224%. The convexity of this bond at this time was 0.820. The relevant implied spot interest rates at each of the cash flow dates are shown alongside.

The cash flow for the December 2009 principal strip is shown at Table 5.11. Note that if one is calling up this security on the Bloomberg® system, the "ticker" is UKTR, comprising the standard UKT (for "United Kingdom Treasury") and the suffix R (from "residual", the Bloomberg term for principal strips). The Bloomberg ticker for coupon strips is UKTS.

Pay date	Cash flow	Spot	Pay date	Cash flow	Spot
7-Jun-99	28,750.00	5.1474	7-Dec-04	28,750.00	4.2746
7-Dec-99	28,750.00	4.9577	7-Jun-05	28,750.00	4.3168
7-Jun-00	28,750.00	4.8511	7-Dec-05	28,750.00	4.3599
7-Dec-00	28,750.00	4.7376	7-Jun-06	28,750.00	4.3738
7-Jun-01	28,750.00	4.6413	7-Dec-06	28,750.00	4.3881
7-Dec-01	28,750.00	4.5481	7-Jun-07	28,750.00	4.3603
7-Jun-02	28,750.00	4.4614	7-Dec-07	28,750.00	4.3326
7-Dec-02	28,750.00	4.3962	7-Jun-08	28,750.00	4.2942
7-Jun-03	28,750.00	4.3307	7-Dec-08	28,750.00	4.2548
7-Dec-03	28,750.00	4.2654	7-Jun-09	28,750.00	4.2153
7-Jun-04	28,750.00	4.2696	7-Dec-09	1,028,750.00	4.1759
1 Nominal	1,000,000		4 Present value	1,141,925.84	
2 Duration	8.33		5 Accrued interest	10,425.82	
3 Total cash flow	1,632,500.00		6 Previous coupon date		

**Table 5.10:** Cash flow analysis Treasury 5<sup>3</sup>/<sub>4</sub>% 2009, yield 4.2224%. (Source: Bloomberg).

The yield on the principal strip at this time was 4.1482%, which corresponds to a price of 64.13409 per £100 nominal. Given that the yield curve is inverted at this time, this is what is expected, a yield lower than the gross redemption yield for the coupon gilt. For a holding of £1 million nominal there is only one cash flow, the redemption payment of £1 million on the redemption date. The convexity for the principal strip was 1.175, which illustrates the higher convexity property of strips versus coupon bonds. Comparing the tables we can see also that duration for the strip is higher than that for the coupon gilt. Note the analysis for the principal strip gives us a slightly different spot curve.

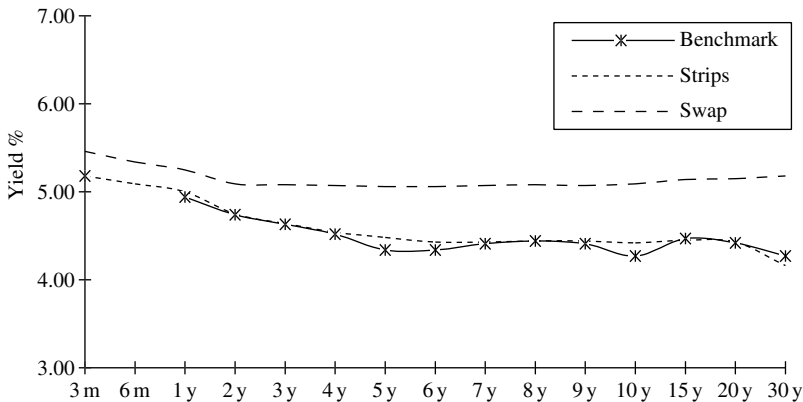
Pay date	Cash flow	Spot	Pay date	Cash flow	Spot
7-Jun-99	0.00	5.1835	7-Dec-04	0.00	4.2683
7-Dec-99	0.00	4.9577	7-Jun-05	0.00	4.3102
7-Jun-00	0.00	4.8509	7-Dec-05	0.00	4.3529
7-Dec-00	0.00	4.7373	7-Jun-06	0.00	4.3672
7-Jun-01	0.00	4.6411	7-Dec-06	0.00	4.3821
7-Dec-01	0.00	4.5480	7-Jun-07	0.00	4.3571
7-Jun-02	0.00	4.4613	7-Dec-07	0.00	4.3322
7-Dec-02	0.00	4.3952	7-Jun-08	0.00	4.2937
7-Jun-03	0.00	4.3290	7-Dec-08	0.00	4.2543
7-Dec-03	0.00	4.2629	7-Jun-09	0.00	4.2148
7-Jun-04	0.00	4.2651	7-Dec-09	1,000,000.00	4.1753
1 Nominal	1,000,000		4 Present value	641,340.87	
2 Duration	10.82		5 Accrued interest	0.00	
3 Total cash flow	1,000,000.00		6 Previous coupon date		

**Table 5.11:** Cash flow analysis Treasury 5<sup>3</sup>/<sub>4</sub>% 2009 Principal Strip, yield 4.1482%. (Source: Bloomberg).

Pay date	Cash flow	Spot	Pay date	Cash flow	Spot
7-Jun-99	0.00	5.2025	7-Dec-04	0.00	4.3217
7-Dec-99	0.00	5.0151	7-Jun-05	0.00	4.3672
7-Jun-00	0.00	4.8927	7-Dec-05	0.00	4.4136
7-Dec-00	0.00	4.7633	7-Jun-06	0.00	4.4353
7-Jun-01	0.00	4.6881	7-Dec-06	0.00	4.4576
7-Dec-01	0.00	4.6108	7-Jun-07	0.00	4.4299
7-Jun-02	0.00	4.5138	7-Dec-07	0.00	4.4023
7-Dec-02	0.00	4.4450	7-Jun-08	0.00	4.3608
7-Jun-03	0.00	4.3761	7-Dec-08	0.00	4.3183
7-Dec-03	0.00	4.3074	7-Jun-09	0.00	4.2758
7-Jun-04	0.00	4.3141	7-Dec-09	1,000,000.00	4.2333
1 Nominal	1,000,000		4 Present value	641,340.87	
2 Duration	10.82		5 Accrued interest	0.00	
3 Total cash flow	1,000,000.00		6 Previous coupon date		

**Table 5.12:** Cash flow analysis, December 2009 Coupon Strip, yield 4.4263%.  
(Source: Bloomberg).

Finally we show at Table 5.12 the cash flow analysis for a coupon strip maturing on 7 December 2009. The yield quote for this coupon strip at this time was 4.4263%, corresponding to a price of 62.26518 per £100 nominal. This illustrates the point on strip prices we referred to earlier; according to a strict interpretation of the law of one price, all strips maturing on the same date should have the same price (because, why should an investor have a different yield requirement for the same nominal future cash flow depending on whether the £100 nominal they receive on maturity was sourced from a coupon payment or from the principal payment?). However, the liquidity differences between principal and



**Figure 5.5:** Spot yield curves for 5.75% 2009 gilt, principal and coupon strips, 10 February 1999. (Source: Bloomberg).

coupon strips make the former easier to trade and also more sought after by investors, which explains the difference in yield between principal and coupon strips. The more liquid instrument trades at the lower yield.

A graph of the spot yield curves, drawn from the rates for the coupon gilt, principal and coupon strips is shown at Figure 5.5.

## 5.6 Future developments in strips

The gilt strips market is a relatively new market and there remains the possibility of new products being introduced at some point in the future. The BoE and DMO are in regular consultation with the market as part of their normal business activity in gilts, and should there be a large demand for new developments then new instruments may be introduced. Products that have already been mooted include deferred payment gilts, which would not make coupon payments for a set period after issue, and annuities, which would comprise a stream of coupon payments, with no principal repayment at maturity. The DMO has stated that investors can create these instruments themselves from within the existing strips facility. For example, investors could use strips to create a synthetic deferred payment gilt or annuity by acquiring strips that provide cash flows for specific points in the future. Alternatively investors could purchase the entire term of cash flows from a stripped gilt and then sell the strips that were not required. For similar reasons the BoE originally (and now the DMO) decided against direct issuance of strips, alongside the strips facility. At the present time it is uncertain to what extent demand exists for such direct issues, and what the pattern of demand would be. In any case the current arrangements are sufficient to meet demand, rendering it unnecessary for the central authorities to analyse and identify what this demand is.

Before the start of trading, the BoE consulted with the market on the need for a second pair of coupon dates in addition to the planned and subsequently introduced pair of 7 June and 7 December. An extra set of cash flow dates would increase investor choice. At the inception of the market it was felt that this would reduce available volume and hence liquidity, and therefore was not introduced. However, now that there is greater familiarity with the market this is not an issue, and in 2002 there were two gilts with March and September coupon dates.

In the BoE's original consultation paper on the strips market, the possibility of issuing index-linked strips was raised. Certain investment institutions (generally long-dated bond investors such as pension funds, who currently also invest in coupon index-linked gilts) have expressed interest in such instruments. Allowing the market to strip indexed bonds would enable them to create inflation-linked products that are more tailored to clients' needs, such as indexed annuities or deferred payment indexed bonds. In overseas markets where stripping of indexed government bonds does take place, the resulting strip is an individual uplifted cash flow. An interesting strips facility exists in the New Zealand market, where the cash flows are separated into three components: the principal, the principal inflation adjustment and the set of inflation-linked coupons (that is, an indexed annuity). In the UK, however, it is felt that the small issue size of index-linked gilts and their coupons would result in a strips market of very low liquidity. The authorities have stated that the case for index-linked gilts will be reviewed in the light of experience gained with conventional strips; indeed all possibilities are under constant

review and may be introduced if the market develops a significant demand for these types of instruments. Hence as the gilt strips market develops we can expect to see new developments and possibly new structures being introduced. If this contributes to maintaining the attraction of gilts to domestic and overseas investors, it will be to the advantage of sterling markets as a whole.

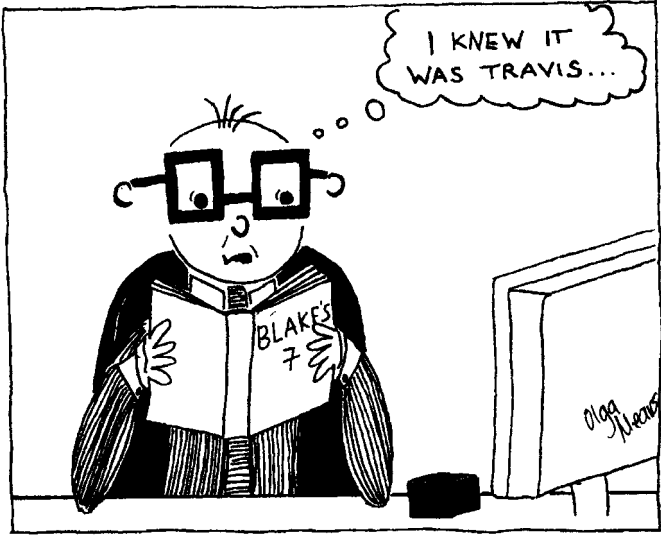
# Appendices

## Appendix 5.1: List of gilt strip prices and yields, March 1999

Strip	Price	Yield	Modified duration	Convexity	Strip	Price	Yield	Modified duration	Convexity
Jun-99 C	98.692	5.068	0.26	0.002	Jun-13 C	51.427	4.714	13.950	2.013
Dec-99 C	96.355	4.918	0.75	0.009	Dec-13 C	50.278	4.706	14.440	2.156
Jun-00 C	93.930	5.009	1.23	0.021	Jun-14 C	49.128	4.706	14.930	2.301
Dec-00 P	91.586	5.036	1.72	0.038	Dec-14 C	48.012	4.705	15.420	2.452
Dec-00 C	91.685	4.973	1.72	0.038	Jun-15 C	46.886	4.708	15.900	2.607
Jun-01 C	89.462	4.976	2.21	0.060	Dec-15 P	46.100	4.670	16.390	2.767
Dec-01 C	87.348	4.949	2.7	0.086	Dec-15 C	45.836	4.705	16.390	2.766
Jun-02 P	85.467	4.867	3.19	0.117	Jun-16 C	44.865	4.693	16.880	2.932
Jun-02 C	85.350	4.910	3.19	0.117	Dec-16 C	43.889	4.686	17.370	3.102
Dec-02 C	83.426	4.861	3.68	0.154	Jun-17 C	42.922	4.682	17.860	3.277
Jun-03 C	81.581	4.824	4.17	0.194	Dec-17 C	41.986	4.676	18.350	3.457
Dec-03 P	80.158	4.691	4.66	0.240	Jun-18 C	41.049	4.673	18.840	3.640
Dec-03 C	79.805	4.786	4.66	0.240	Dec-18 C	40.165	4.665	19.330	3.830
Jun-04 C	77.897	4.798	5.15	0.290	Jun-19 C	39.311	4.658	19.820	4.023
Dec-04 C	76.067	4.798	5.63	0.345	Dec-19 C	38.486	4.648	20.310	4.225
Jun-05 C	74.355	4.783	6.12	0.405	Jun-20 C	37.737	4.632	20.800	4.428
Dec-05 P	72.819	4.740	6.61	0.470	Dec-20 C	36.835	4.638	21.290	4.635
Dec-05 C	72.661	4.774	6.61	0.469	Jun-21 P	36.204	4.612	21.780	4.849
Jun-06 C	70.960	4.776	7.1	0.539	Jun-21 C	36.023	4.635	21.770	4.848
Dec-06 C	69.278	4.781	7.59	0.613	Dec-21 C	35.426	4.608	22.270	5.067
Dec-06 P	69.304	4.775	7.59	0.613	Jun-22 C	34.699	4.599	22.760	5.290
Jun-07 C	67.747	4.765	8.08	0.692	Dec-22 C	34.005	4.587	23.250	5.518
Dec-07 C	66.237	4.753	8.57	0.776	Jun-23 C	33.321	4.578	23.740	5.750
Dec-07 P	66.408	4.723	8.57	0.776	Dec-23 C	32.678	4.565	24.230	5.988
Jun-08 C	64.798	4.733	9.06	0.866	Jun-24 C	32.043	4.553	24.720	6.231
Dec-08 C	63.287	4.735	9.55	0.959	Dec-24 C	31.432	4.538	25.220	6.482
Jun-09 C	61.852	4.731	10.04	1.056	Jun-25 C	30.892	4.519	25.710	6.734
Dec-09 P	61.804	4.518	10.53	1.161	Dec-25 C	30.343	4.502	26.200	6.991
Dec-09 C	60.479	4.723	10.52	1.159	Jun-26 C	29.818	4.484	26.690	7.252
Jun-10 C	59.167	4.711	11.01	1.266	Dec-26 C	29.314	4.466	27.180	7.519
Dec-10 C	57.798	4.711	11.5	1.379	Jun-27 C	28.816	4.448	27.670	7.790
Jun-11 C	56.460	4.713	11.99	1.496	Dec-27 C	28.316	4.432	28.160	8.067
Dec-11 C	55.152	4.713	12.48	1.618	Jun-28 C	27.853	4.413	28.650	8.350
Jun-12 C	53.881	4.713	12.97	1.745	Dec-28 C	27.339	4.402	29.140	8.637
Dec-12 C	52.640	4.713	13.46	1.877	Dec-28 P	27.635	4.365	29.150	8.640

P-Principal strip; C-Coupon strip.

**Table 5.13:** Strip prices and yields, March 1999. (Source: HSBC, Barclays Capital, Bloomberg).



And when I'm lying in my bed  
I think about life and I think about death...  
And neither one particularly appeals to me

– The Smiths, *Nowhere Fast* 1985

# 6 The Gilt Repo Market

In this chapter we describe and examine the market in United Kingdom gilt repo, a recent development but an example of an efficient and liquid market. The introduction of repo was part of a range of structural changes and reform undertaken in the gilt market to bring market practice up to date. These changes included changes in quotation convention to decimals in place of tick pricing, and the introduction of a market in zero-coupon gilts or strips. The repo market has been arguably the most successful element of these market reforms.

## 6.1 Introduction

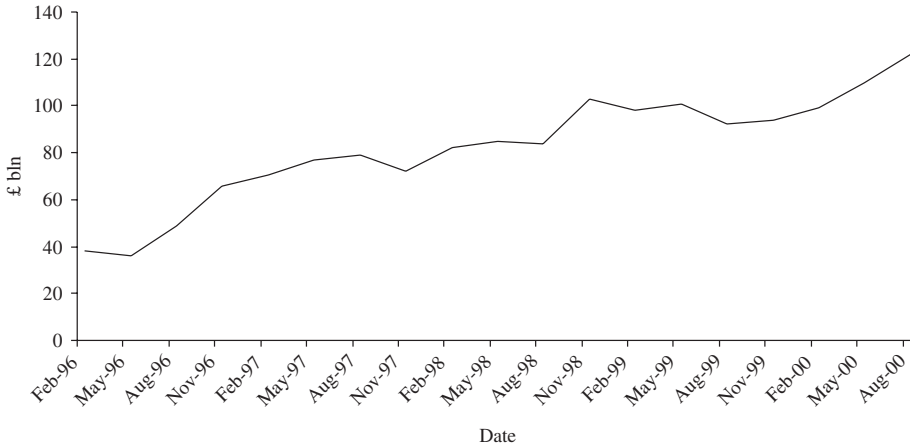
The repo market in the United Kingdom is relatively new, having begun only on 2 January 1996. It was introduced as a “big bang” with all institutions and structures in place before the start of trading, and implementation was smooth and trouble-free. Before the advent of an open market in repo, stock borrowing and lending in the gilt market was available only to *gilt-edged market makers* (GEMMs), dealing through approved intermediaries known as *Stock Exchange Money Brokers* (SEMBs). The introduction of an open gilt repo allowed all market participants to borrow and lend gilts. Additional market reforms also liberalised gilt stock lending by removing the restrictions on who could borrow and lend stock, thus ensuring a “level playing field” between the two types of transaction. The *gilt-edged stock lending agreement* (GESLA) was also updated to ensure that it dovetailed with the new gilt repo legal agreement; the revised GESLA was issued in December 1995 and repo and stock lending are inter-linked aspects of the new market.

In the run up to the start of repo trading market practitioners and regulators compiled a set of recommended market practices, set out in the Gilt Repo Code of Best Practice. The associated legal agreement is the PSA/ISMA Global Master Repurchase Agreement, with an annexe describing special features of gilts such as the use of delivery-by-value (DBV) within the CREST settlement mechanism.

The market participants in gilt repo include commercial and investment banks, fund managers and local authority and corporate treasurers.

The repo market grew to about £50 billion of repos and stock lending outstanding in the first two months of operation, and further growth took it to nearly £95 billion by February 1997, of which £70 billion was in repos. This figure fell to about £75 billion by November 1998, compared with £100 billion for sterling certificates of deposit (CDs). During 1999 the size of the market stabilised and grew by only a relatively small amount; the amount outstanding stood at £100 billion in November 1999. Figure 6.1 shows the amount of gilt





**Figure 6.1:** Gilt repo outstanding. (Source: BoE, used with permission).

repo outstanding to August 2000. Following rapid initial growth, a Bank of England report suggested that further significant growth in the market would require “structural innovation”.<sup>1</sup> These would include the introduction of repo *netting* and more widespread electronic trading mechanisms.

Table 6.1 shows the composition of the sterling money market during 2000 and 2001; gilt repo, interbank deposits and CDs make up by far the largest share of the market by amount outstanding. This is noteworthy given the relatively recent introduction of repo,

Interbank	CDs	T-Bills	Amounts outstanding: £bn							Other <sup>^</sup>	Total
			Bank bills	CP	Gilt repo	Sell/buy-backs	Stock lending	Local authority bills			
*1990	89	53	9	23	5	–	–	–	2	181	
*1995	93	66	8	20	6	–	–	–	2	195	
1998	150	122	1	17	10	95~	2	35~	1	303	
1999	155	135	4	14	13	99~	3	49~	0	324	
Feb 2000	155	127	2	14	13	100	2	51	0	464	
May 2000	165	138	2	14	17	123	3	54	0	516	
Q4 2000	151	130	3	11	18	127	6	57	0	503	
Q1 2001	171	141	–	13	19	126	–	67	7	544	

\* 1990 and 1995 data are end-March; otherwise end-year.

~ End-November data.

^ “Other” comprises T-Bills, sell/buy backs and local authority bills.

**Table 6.1:** Sterling money markets. (Source: BoE, QB 8/00, Spring 2001, Summer 2001. Used with permission).

<sup>1</sup> *Quarterly Bulletin*, February 2000.

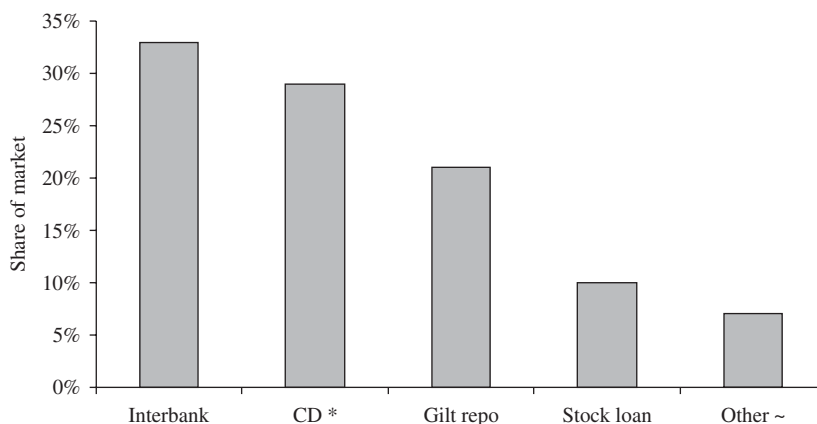
£bn	1997	1998				1999			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
<b>Gilts</b>									
Conventional	7.0	7.0	6.0	6.0	5.0	6.0	6.0	4.0	na
Index-linked	0.2	0.1	0.2	0.1	0.1	0.1	0.1	0.0	na
<b>Money markets</b>									
Gilt repo	14.8	11.4	16.8	14.7	15.5	12.6	13.5	15.8	12.4
Overnight interbank	6.1	7.7	7.8	7.1	7.4	8.2	8.3	7.8	7.6

na = not available.

**Table 6.2:** Average daily market turnover, nominal amounts.  
(Source: BoE, London Stock Exchange).

while its introduction coincided with an increase in the size of the stock loan market. Table 6.2 shows that the average daily turnover in gilt repo approached £16 billion during 1999.

Table 6.1 and Figure 6.2 illustrate some interesting developments in sterling money markets since the advent of gilt repo. The Certificate of Deposit (CD) market has grown substantially, partly because the growth of the gilt repo and stock lending market has contributed to demand for CDs for use as collateral in stock loans, and also because banks will use the CD market to enhance yields, as part of credit intermediation between the money market and gilt repo. The BoE suggested this growth occurred partly as a result of two factors:<sup>2</sup>



\* Bank and building society CDs

~ Includes Treasury bills, eligible and local authority bills, commercial paper, and sell/buy-backs

**Figure 6.2:** Sterling money markets: outstanding amounts, November 1999. (Source: BoE).  
Used with permission.

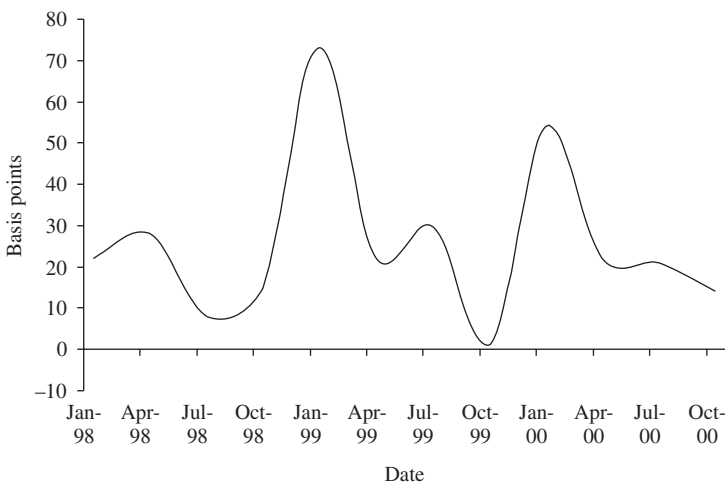
<sup>2</sup> See *Quarterly Bulletin*, February 2000 pp. 40–41.

- the liquidity regime for sterling money markets, introduced by the Bank in 1996, increased the attractions of CD funding for banks, as their required liquidity holdings were allowed to be offset by holding other banks' CDs;
- as we noted above, CDs used as collateral in the stock loan market (making possible stock loan/repo market intermediation trade) increases the demand to hold these instruments.

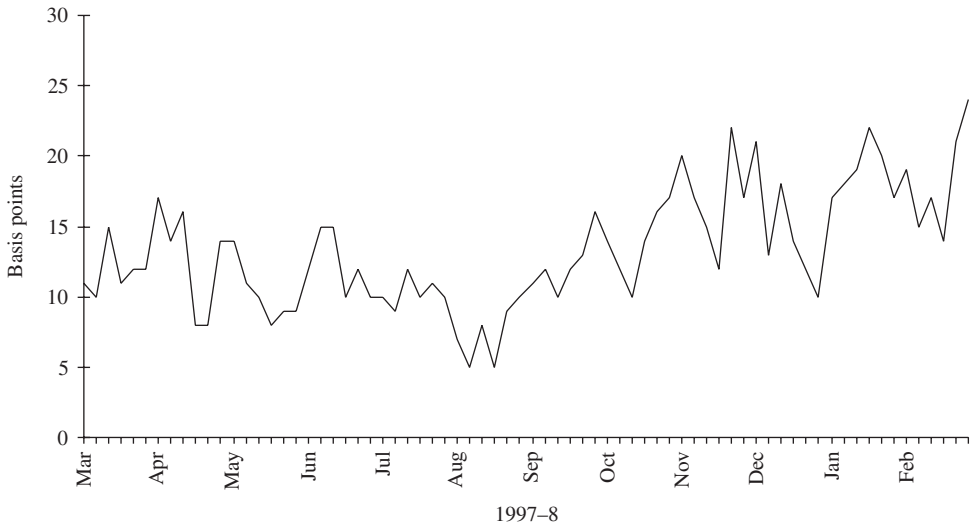
The stock loan market grew from £35 billion to £49 billion in the year to November 1999. This growth resulted from the “complementary relationship” (BoE, *ibid*) between the stock loan and repo markets, and intermediation between them by participants who had access to both markets. The continuing popularity of stock lending reflects its popularity with institutional investors, many of the smaller size ones of which prefer to lend their portfolio holdings for a fee, rather than sell in repo. This obviates the need for them to monitor an interest-rate position or reinvest cash collateral.

So gilt repo has developed alongside growth in the existing unsecured money markets. There has been a visible shift in short-term money market trading patterns from unsecured to secured money. According to the Bank market participants estimate that gilt repo now accounts for about half of all overnight transactions in the sterling money markets. The repo general collateral (GC) rate tends to trade below the interbank rate, on average about 10–15 basis points below, reflecting its status as government credit. The gap is less obvious at very short maturities, due to the lower value of such credit over the short-term and also reflecting the higher demand for short-term funding through repo by securities houses that may not have access to unsecured money.

Figures 6.3, 6.4 and 6.5 show the spread between one-month repo and interbank rates, the spread for three-month GC repo early on during the market and for the two-week and one-month GC repo during 1999. Another effect of gilt repo on the money market is a possible association with a reduction in the volatility of overnight unsecured rates. Fluctuations in the overnight unsecured market have been reduced since the start of an open repo

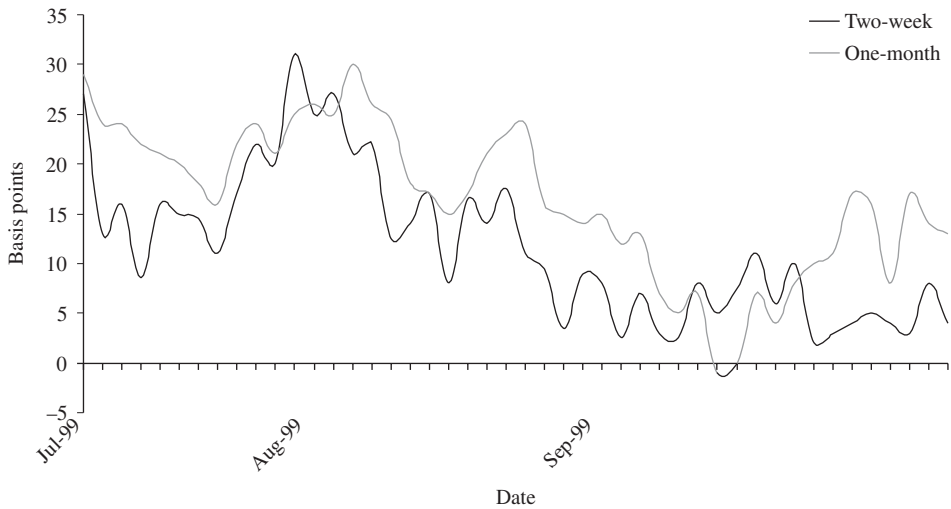


**Figure 6.3:** Spread between one-month repo and interbank rates. (Source: BoE).



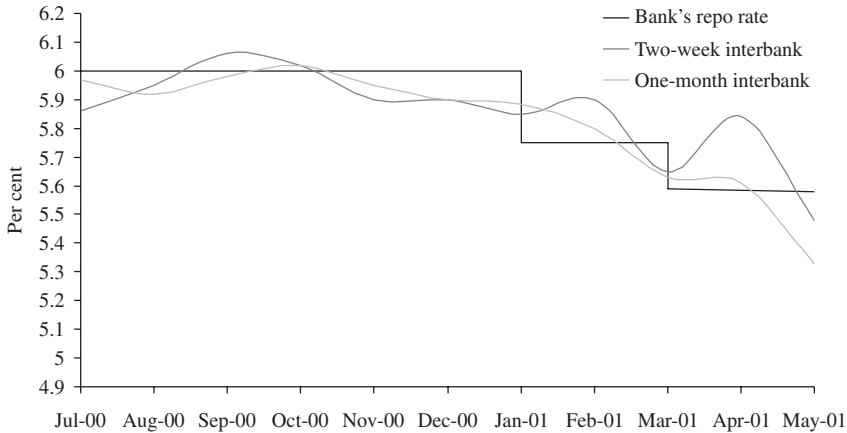
Middle rates at 10.15am

**Figure 6.4:** Three-month interbank rate minus three-month gilt repo GC rate during 1997–1998. (Source: Bank of England, Bloomberg).



**Figure 6.5:** The spread for the two-week and one-month GC repo during 1999. (Source: Bloomberg).

market, although the evidence is not conclusive. This may be due to repo providing an alternative funding method for market participants, which may have reduced pressure on the unsecured market in overnight funds. It may also have enhanced the ability of financial intermediaries to distribute liquidity.



**Figure 6.6:** BoE repo rate, two-week and one-month interbank mid-rates.

The spread between the BoE repo rate, the two-week and the one-month interbank mid-rates is shown in Figure 6.6.

## 6.2 The basics of repo

A repo agreement is a transaction in which one party sells securities to another, and at the same time and as part of the same transaction commits to repurchase identical securities on a specified date at a specified price. The seller delivers securities and receives cash from the buyer. The cash is supplied at a predetermined rate – *the repo rate* – that remains constant during the term of the trade. On maturity the original seller receives back collateral of equivalent type and quality, and returns the cash plus repo interest. One party to the repo requires either the cash or the securities and provides *collateral* to the other party, as well as some form of compensation for the temporary use of the desired asset. Although legal title to the securities is transferred, the seller retains both the economic benefits and the market risk of owning them. This means that the “seller” will suffer if the market value of the collateral drops during the term of the repo, as they still retain beneficial ownership of the collateral. The “buyer” in a repo is not affected in P/L account terms if the value of the collateral drops, although as we shall see later, there will be other concerns for the buyer if this happens.

We have given here the legal definition of repo. However the purpose of the transaction as we have described above is to borrow or lend cash, which is why we have used inverted commas when referring to sellers and buyers. The “seller” of stock is really interested in borrowing cash, on which they will pay interest at a specified interest rate. The “buyer” requires security or *collateral* against the loan they have advanced, and/or the specific security to borrow for a period of time. The first and most important thing to state is that repo is a secured loan of cash, and would be categorised as a money market yield instrument.<sup>3</sup>

<sup>3</sup> That is, a money market instrument quoted on a yield instrument, similar to a bank deposit or a Certificate of Deposit. The other class of money market products are *discount* instruments such as Treasury Bills or Commercial Paper.

## 6.3 The classic repo

The *classic repo* is the instrument encountered in the US, UK and other markets. In a classic repo one party will enter into a contract to sell securities, simultaneously agreeing to purchase them back at a specified future date and price. The securities can be bonds or equities but also can be money market instruments such as T-bills. The buyer of the securities is handing over cash, which on the termination of the trade will be returned to them, and on which they will receive interest.

The seller in a classic repo is selling or *offering* stock, and therefore receiving cash, whereas the buyer is buying or *bidding* for stock, and consequently paying cash. So if the one-week repo interest rate is quoted by a market making bank as “5½–5¼”, this means that the market maker will bid for stock, that is, lend the cash, at 5.50% and offers stock or pays interest on cash at 5.25%.

### 6.3.1 Illustration of classic repo

There will be two parties to a repo trade, let us say Bank A (the seller of securities) and Bank B (the buyer of securities). On the trade date the two banks enter into an agreement whereby on a set date, the *value* or *settlement* date, Bank A will sell to Bank B a nominal amount of securities in exchange for cash.<sup>4</sup> The price received for the securities is the market of the stock on the value date. The agreement also demands that on the termination date Bank B will sell identical stock back to Bank A at the previously agreed price, and consequently Bank B will have its cash returned with interest at the agreed repo rate.

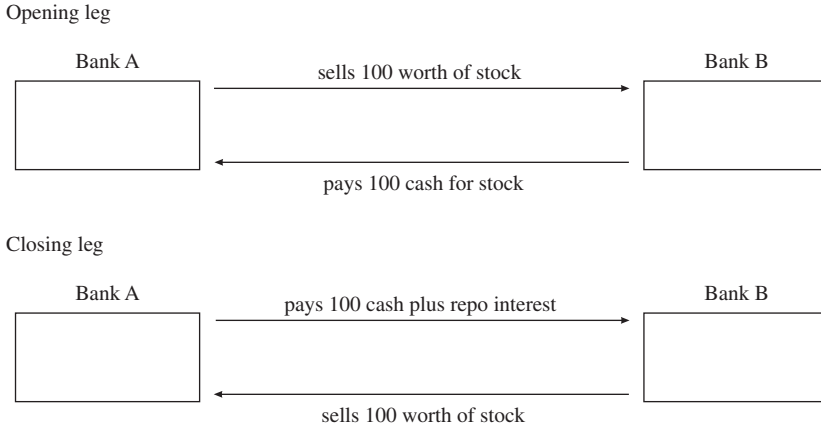
In essence a repo agreement is a secured loan (or *collateralised* loan) in which the repo rate reflects the interest charged.

On the value date stock and cash change hands. This is known as the start date, *first leg* or *opening leg*, while the termination date is known as the *second leg* or *closing leg*. When the cash is returned to Bank B, it is accompanied by the interest charged on the cash during the term of the trade. This interest is calculated at a specified rate known as the *repo rate*. It is important to remember that although in legal terms the stock is initially “sold” to Bank B, the economic effects of ownership are retained with Bank A. This means that if the stock falls in price it is Bank A that will suffer a capital loss. Similarly if the stock involved is a bond and there is a coupon payment during the term of trade, this coupon is to the benefit of Bank A, and although Bank B will have received it on the coupon date, it must be handed over on the same day or immediately after to Bank A. This reflects the fact that although legal title to the collateral passes to the repo buyer, economic costs and benefits of the collateral remain with the seller.

A classic repo transaction is subject to a legal contract signed in advance by both parties. A standard document will suffice; it is not necessary to sign a legal agreement prior to each transaction.

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<sup>4</sup> The two terms are not necessarily synonymous. The value date in a trade is the date on which the transaction acquires value, for example the date from which accrued interest is calculated. As such it may fall on a non-business day such as a weekend or public holiday. The settlement date is the day on which the transaction settles or *clears*, and so can only fall on a working day.



**Figure 6.7:** Classic repo transaction.

Note that although we have called the two parties in this case “Bank A” and “Bank B”, it is not only banks that get involved in repo transactions, and we have used these terms for the purposes of illustration only.

The basic mechanism is illustrated in Figure 6.7.

A seller in a repo transaction is entering into a repo, whereas a buyer is entering into a *reverse repo*. In Figure 6.7 the repo counterparty is Bank A, while Bank B is entering into a reverse repo. That is, a reverse repo is a purchase of securities that are sold back on termination. As is evident from Figure 6.7 every repo is a reverse repo, and the name given is dependent on from whose viewpoint one is looking at the transaction.<sup>5</sup>

### 6.3.2 Examples of classic repo

The basic principle is illustrated with the following example. This considers a *specific* repo, that is one in which the collateral supplied is specified as a particular stock, as opposed to a *general collateral* (GC) trade in which a basket of collateral can be supplied, of any particular issue, as long as it is of the required type and credit quality.

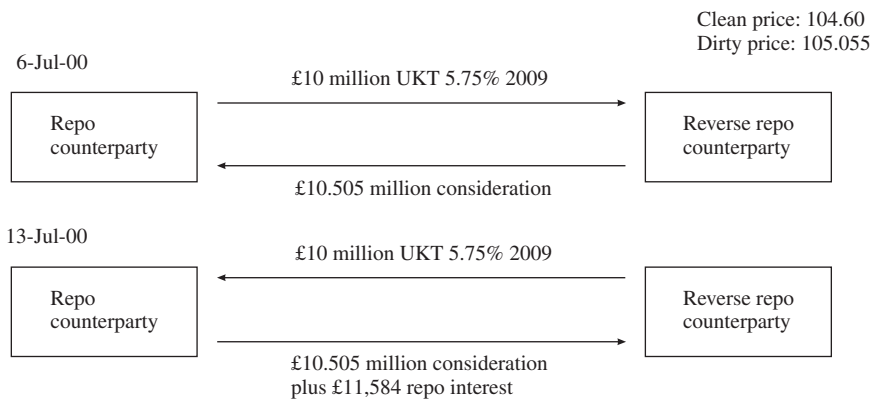
We consider first a classic repo in the United Kingdom gilt market between two market counterparties, in the 5.75% Treasury 2009 gilt stock. The terms of the trade are given in Table 6.3 and it is illustrated at Figure 6.8.

The repo counterparty delivers to the reverse repo counterparty £10 million nominal of the stock, and in return receives the purchase proceeds. In this example no margin has been taken so the start proceeds are equal to the market value of the stock which is

<sup>5</sup> Note that the guidelines to the syllabus for the Chartered Financial Analyst examination, which is set by the Association for Investment Management and Research, define repo and reverse repo slightly differently. Essentially a “repo” is conducted by a bank counterparty and a “reverse repo” is conducted by an investment counterparty or non-financial counterparty. Another definition states that a “repo” is any trade where the bank counterparty is offering stock (borrowing cash) and a “reverse repo” is any trade where the non-bank counterparty is borrowing cash.

Trade date	5 July 2000
Value date	6 July 2000
Repo term	1 week
Termination date	13 July 2000
Collateral (stock)	UKT 5.75% 2009
Nominal amount	£10,000,000
Price	104.60
Accrued interest (29 days)	0.4556011
Dirty price	105.055601
Settlement proceeds ( <i>wired amount</i> )	£10,505,560.11
Repo rate	5.75%
Repo interest	£11,584.90
Termination proceeds	£10,517,145.01

**Table 6.3:** Terms of classic repo trade.



**Figure 6.8:** Classic repo trade.

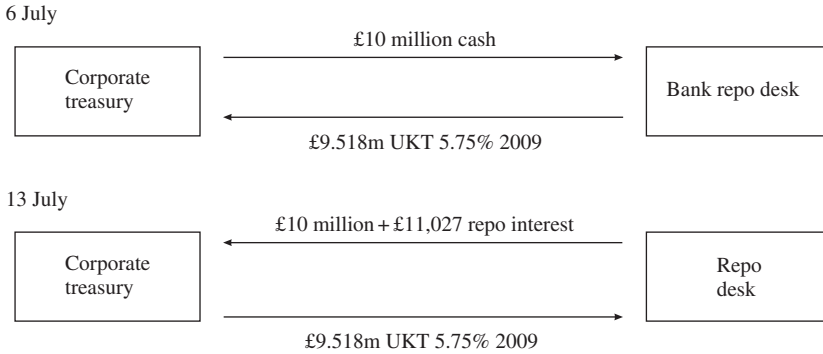
£10,505,560.11. It is common for a rounded sum to be transferred on the opening leg. The repo interest is 5.75%, so the repo interest charged for the trade is:

$$10,505,560 \times 5.75\% \times \frac{7}{365}$$

or £11,584.90. The sterling market day-count basis is actual/365, so the repo interest is based on a seven-day repo rate of 5.75%. Repo rates are agreed at the time of the trade and are quoted, like all interest rates, on an annualised basis. The settlement price (dirty price) is used because it is the market value of the bonds on the particular trade date and therefore indicates the cash value of the gilts. By doing this the cash investor minimises credit exposure by equating the value of the cash and the collateral.

On termination the repo counterparty receives back its stock, for which it hands over the original proceeds plus the repo interest calculated above.





**Figure 6.9:** Corporate treasury classic repo.

What if a counterparty is interested in investing £10 million against gilt collateral? Let us assume that a corporate treasury function with surplus cash wishes to invest this amount in repo for a one-week term. It invests this cash with a bank that deals in gilt repo.

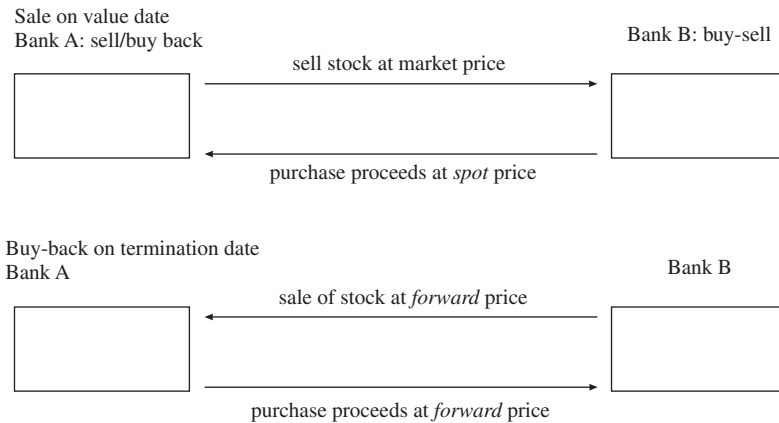
The terms of the trade are identical to that in Table 6.3, including the term of the trade and the repo rate; however the opening leg wired amount is entered as £10 million, which is the cash being invested. Therefore the nominal value of the gilt collateral required will be different, as we now require a market value of this stock of £10 million. From Figure 6.9 we see that this is £9,518 million. The cash amount is different from the example at Figure 6.8 so of course the repo interest charged is different, and is £11,027 for the seven-day term.

The diagram at Figure 6.9 illustrates the transaction.

## 6.4 The sell/buy-back

In addition to classic repo there exists *sell/buy-back*. A sell/buy-back is defined as an outright sale of a bond on the value date, and an outright repurchase of that bond for value on a *forward* date. The cash flows therefore become a sale of the bond at a *spot* price, followed by repurchase of the bond at the *forward* price. The forward price calculated includes the interest on the repo, and is therefore a different price to the spot price. That is, repo interest is realised as the difference between the spot price and forward price of the collateral at the start and termination of the trade. The sell/buy-back is entered into for the same considerations as a classic repo, but was developed initially in markets where no legal agreement existed to cover repo transactions, and where the settlement and IT systems of individual counterparties were not equipped to deal with repo. Over time sell/buy-backs have become the convention in certain markets, most notably Italy, and so the mechanism is still retained. In many markets therefore sell/buy-backs are not covered by a legal agreement, although the standard legal agreement used in classic repo now includes a section that describes them.<sup>6</sup>

<sup>6</sup> This is the PSA/ISMA Global Master Repurchase Agreement.



**Figure 6.10:** Sell/buy-back transaction.

A sell/buy-back is a spot sale and forward repurchase of bonds transacted simultaneously, and the repo rate is not explicit, but is implied in the forward price. Any coupon payments during the term are paid to the seller. But this is done through incorporation into the forward price, so the seller will not receive it immediately, but on termination. This is a disadvantage when compared to classic repo. However, there will be compensation payable if a coupon is not handed over straight away, usually at the repo rate implied in the sell/buy-back. As sell/buy-backs are not subject to a legal agreement in most cases, in effect the seller has no legal right to any coupon, and there is no provision for marking-to-market and *variation margin*. This makes the sell/buy-back a higher risk transaction when compared to classic repo, even more so in volatile markets.

A general diagram for the sell/buy-back is given at Figure 6.10.

Note that sell/buy-backs are frowned upon by the Bank of England and so are not observed in the gilt market.

## 6.5 Stock lending

### 6.5.1 Definition

Stock lending or *securities lending* is defined as a temporary transfer of securities in exchange for collateral. It is not a repo in the normal sense; there is no sale or repurchase of the securities. The temporary use of the desired asset (the stock that is being borrowed) is reflected in a fixed fee payable by the party temporarily taking the desired asset. In stock loan, the lender does not monitor interest rates during the term of the trade, but instead realises value by receiving this fixed fee during the term of the loan. This makes administration of stock lending transactions more straightforward compared to the repo. The formal definition of a stock loan is a contract between two parties in which one party lends securities to another for a fixed or *open* term. The party that borrows must supply collateral to the stock lender, which can be other high quality securities, cash or a letter of credit. This protects against credit risk. Fabozzi (2001) states that in the US the most common type of collateral is cash; however, in the UK market it is quite common for other securities to be

given as collateral, typically gilts. In addition the lender charges a fixed fee, usually quoted as a basis point charge on the market value of the stock being lent, payable by the borrower on termination. The origins and history of the stock lending market are different from that of the repo market. The range of counterparties is also different, although of course a large number of counterparties are involved in both markets. Most stock loans are on an “open” basis, although term loans also occur.

Institutional investors such as pension funds and insurance companies often prefer to enhance the income from their fixed interest portfolios by lending their bonds, for a fee, rather than entering into repo transactions. This obviates the need to set up complex settlement and administration systems, as well as the need to monitor what is an interest rate position. Initial *margin* is given to institutional lenders of stock, usually in the form of a greater value of collateral stock than the market value of the stock being lent.

### 6.5.2 *Basic concepts*

Stock lending transactions are the transfer of a security or basket of securities from a lending counterparty, for a temporary period, in return for a fee payable by the borrowing counterparty. During the term of the loan the stock is lent out in exchange for collateral, which may be in the form of other securities or cash. If other securities are handed over as collateral, they must be high-quality assets such as Treasuries, gilts or other highly-rated paper. Lenders are institutional investors such as pension funds, life assurance companies, local authority treasury offices and other fund managers, and loans of their portfolio holdings are often facilitated via the use of a broking agent, known as a *prime broker* or a clearing agent custodian such as Euroclear or Clearstream. In addition banks and securities houses that require stock to cover short positions sometimes have access to their own source of stock lenders, for example clients of their custody services.

Stock lending is not a sale and repurchase in the conventional sense but is used by banks and securities houses to cover short positions in securities put on as part of market making or proprietary trading activity. In some markets, for example, the Japan equity market, regulations require a counterparty to have arranged stock lending before putting on the short trade. Other reasons why banks may wish to enter into stock loan (or stock borrowing, from their viewpoint) transactions include:

- where they have effected a purchase, and then sold this security on, and their original purchase has not settled, putting them at risk of failing on their sale;
- as part of *disintermediation* between the stock loan market and the repo and unsecured money market.

An institution that wishes to borrow stock must pay a fee for the term of the loan. This is usually a basis point charge on the market value of the loan, and is payable in arrears on a monthly basis. In the Eurobond market the fee is calculated at the start of the loan, and unless there is a significant change in the market value of the stock, it will be paid at the end of the loan period. In the gilt market the basis point fee is calculated on a daily basis on the market value of the stock that has been lent, and so the total charge payable is not known until the loan maturity. This arrangement requires that the stock be *marked-to-market* at the end of each business day. The fee itself is agreed between the stock borrower and the stock lender at the time of each loan, but this may be a general fee payable for all loans.

There may be a different fee payable for specific stocks, so in this case the fee is agreed on a trade-by-trade basis, depending on the stock being lent out. Any fee is usually for the term of the loan, although it is possible in most markets to adjust the rate through negotiation at any time during the loan. The fee charged by the stock lender is a function of supply and demand for the stock in the market. A specific security that is in high demand in the market will be lent out at a higher fee than one that is in lower demand. For this reason it is important for the Treasury desk<sup>7</sup> to be aware of which stocks are in demand, and more importantly to have a reasonable idea of which stocks will be in demand in the near future. Some banks will be in possession of better *market intelligence* than others. If excessive demand is anticipated, a prospective short seller may borrow stock in advance of entering into the short sale.

The term of a stock loan can be fixed, in which case it is known as a *term loan*, or it can be open. A term loan is economically similar to a classic repo transaction. An open loan is just that: there is no fixed maturity term, and the borrower will confirm on the telephone at the start of each day whether it wishes to continue with the loan or will be returning the security.

As in a classic repo transaction, coupon or dividend payments that become payable on a security or bond during the term of the loan will be to the benefit of the stock lender. In the standard stock loan legal agreement, known as the OSLA agreement,<sup>8</sup> there is no change of beneficial ownership when a security is lent out. The usual arrangement when a coupon is payable is that the payment is automatically returned to the stock lender via its settlement system. Such a coupon payment is known as a *manufactured dividend*.

Clients of prime brokers and custodians will inform their agent if they wish their asset holdings to be used for stock lending purposes. At this point a stock lending agreement is set up between the holder of the securities and the prime broker or custodian. Borrowers of stock are also required to set up an agreement with brokers and custodians. The return to the broker or custodian is the difference between the fee paid by the stock borrower and that paid to the stock lender. Banks that have their own internal lending lines can access this stock at a lower borrowing rate. If they wish to pursue this source they will set up a stock-lending agreement with institutional investors directly.

### 6.5.3 Example of stock loan

We illustrate a stock loan where the transaction is “stock-driven”. Let us assume that a securities house has a requirement to borrow a UK gilt, the 5.75% 2009, for a one-week period. This is the stock in our earlier classic repo and sell/buy-back examples. We presume the requirement is to cover a short position in the stock, although there are other reasons why the securities house may wish to borrow the stock. The bond that it is offering as collateral is another gilt, the 6.50% Treasury 2003. The stock lender, who we may assume is an institutional investor such as a pension fund, but may as likely be another securities house or a bank, requires a margin of 5% as well as a fee of 20 basis points. The transaction is summarised in Table 6.4.

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<sup>7</sup> Or whichever desk is responsible for covering short positions by borrowing or reverse-repoing stock.

<sup>8</sup> After the trade association overseeing the stock loan market.

Value date	6 July 2000
Termination date	13 July 2000
Stock borrowed	5.75% 2009
Nominal borrowed	£10 million
Term	1 week
Loan value	£10,505,560.11
Collateral	6.50%
Clean price	102.1
Accrued interest (29 days)	0.5150273
Dirty price	102.615027
Margin required	5%
Market value of collateral required = $10,505,560 \times 1.05$	£11,030,837.35
Nominal value of collateral	£10,749,729
Stock loan fee (20 bps)	£402.95

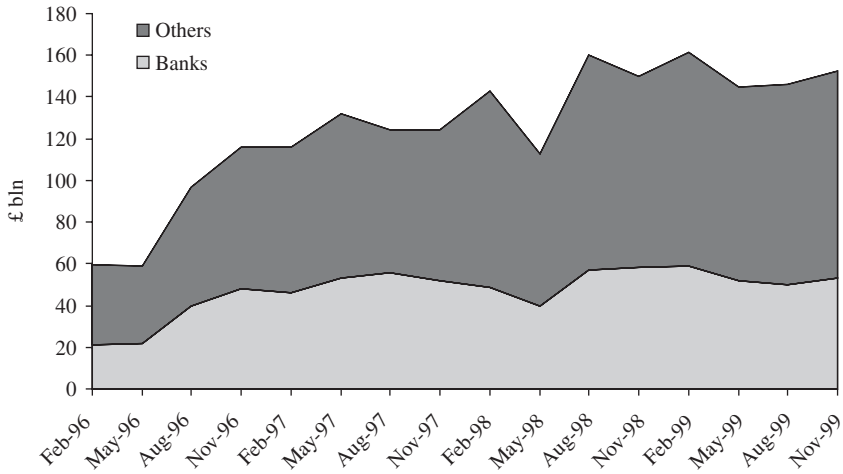
**Table 6.4:** Stock loan transaction.

Note that in reality, in the gilt market the stock loan fee (here 20 bps) is calculated on the daily mark-to-market stock price, automatically within the gilt settlement mechanism known as CREST CGO, so the final charge is not known until termination. Within the Eurobond market, for example in Clearstream, the fee on the initial loan value is taken, and adjustments are made only in the case of large movements in price.

## 6.6 Market structure

### 6.6.1 Introduction

One of the stated objectives behind introducing gilt repo was to enhance the liquidity of the gilt market and the attraction of gilts as an investment, particularly to overseas investors. The positive impact on this with regard to dealing sizes and bid-offer spreads is difficult to measure, however, as the excess of demand for gilts over supply, particularly at the long end of the yield curve, has resulted in some illiquidity in the market since repo was introduced. Gilt repo has however contributed to improvements in the gilt-edged market-making function, *viz*, since the ability to undertake gilt repo with any counterparty enhances the ability of market makers (GEMMs) to make markets in gilts by improving their access to stock to cover short positions reduces the cost of so doing; overall there has been a reduction in the cost of financing long positions, from above Libor to below Libid. The average cost of borrowing stock has also fallen, according to the BoE. These lower financing and borrowing costs are also available to other market participants. On anecdotal evidence it would appear that gilts are now less likely to trade at anomalous prices, and data from the BoE indicates that the divergence of GEMM quoted yields from its own fitted yield curve has decreased. However, it is difficult to strip out other factors contributing to developments such as these, for instance the extremely competitive world of gilts market-making would also appear to have contributed to gilt prices and quote spreads becoming very keen.



**Figure 6.11:** Breakdown of gilt repo activity by banks and non-banking institutions. (Source: Bank of England).

The ability of all market participants to short gilts and to take and finance or cover their desired positions might be expected to improve the efficiency and liquidity of the gilt market. There is scope for empirical study in this regard. The development of a liquid market in secured money has widened the range of funding and money placement options open to financial and non-financial firms. It may also be associated with a reduction in volatility of overnight interest rates.<sup>9</sup>

Figure 6.11 shows the breakdown of gilt repo market activity between banking institutions and non-banking institutions, which include securities houses, fund managers and broking firms. Although banks' share of the market is higher, recent growth in activity is sourced more from non-banking entities. The latter are more likely to use gilt repo when positioning their book to reflect views on interest rates, whereas banks can also use unsecured money market instruments to do this. The Financial Services Authority's regulatory requirements on liquidity are favourable to banks who hold short-dated gilt portfolios, which leads to corresponding activity in repo.

### 6.6.2 Market participation

The UK market structure comprises both gilt repo and gilt stock lending. Although there are institutions which undertake only one type of activity, there are many institutions trading actively in both areas. For example, an institution that is short of a particular gilt may cover its short position (which could result from either an outright sale or a repo) in either the gilt repo or the stock lending market. Certain institutions prefer to use repo because they feel that the value of a *special* stock is more rapidly and more accurately reflected in the repo

<sup>9</sup> On anecdotal evidence, which sample is limited to the author and his acquaintances in the market (!), the volatility of overnight rates would certainly appear to be much lower in the second half of the 1990s compared to the first half.

than the stock lending market. Some firms have preferred to remain in stock lending because their existing systems and control procedures can accommodate stock lending more readily than repo. For example, a firm may have no cash reinvestment facility or experience of managing interest rate risk. Such a firm will prefer to receive collateral against a stock loan for a fee, rather than interest-bearing cash in a repo. They may also feel that their business does not need or cannot justify the costs of setting up a repo trading facility. In addition the stock lending has benefited from securities houses and banks who trade in both it and repo; for example, borrowing a stock in the lending market, repoing this and then investing the cash in say, the CD market.

Other firms have entered into trading in repo due, for instance to the perception that value from tight stock is more readily obtained in the repo market than in the stock lending market.

Prior to the introduction of repo, no facility was made for the registration of dedicated market makers in gilt repo, in the belief that the market mechanism would result in this taking place as a matter of course. This turned out to be the case; virtually from the start of the market some firms have provided what is in effect a market-making function in gilt repo. These firms include the former stock exchange money brokers (SEMBs), and banks that run large matched books. There are approximately 20 firms, mostly banks and securities houses, which quote two-way repo rates on request, for GC, specifics and specials, up to three months' maturity, although longer-dated trades may also be transacted with relative ease. Examples of such firms are former SEMBs such as Gerrard & King (part of the Old Mutual group), Lazards, Rowe & Pitman (part of the UBS group), and banks such as RBS Financial Markets, Barclays Capital and HSBC. Some firms will quote only to established customers, such as ABN Amro Securities Ltd. Some firms will quote indicative repo rates on screen services such as Reuters and Bloomberg, for example the sterling markets screen from HBOS (formerly Halifax plc), "HBOS", which appears on Bloomberg is shown at Figure 6.12.

A number of sterling broking houses are active in gilt repo. Counterparties still require signed legal documentation to be in place with each other, along with credit lines, before trading can take place. This is not the case in the interbank broking market. A gilt repo agreement is not required with the broker, although of course firms will have counterparty agreements in place with them. Typical of the firms providing broking services are Tullet & Tokyo, Tradition Bond Brokers, Prebon Yamane and King & Shaxson Bond Brokers. Brokers tend to specialise in different aspects of the gilt market. For example, some concentrate on GC repo, and others on *specials* and *specifics*; some on very short maturity transactions and others on longer-term trades. Brokerage is usually 1 basis point of the total nominal amount of the bond transferred for GC, and 2 basis points for specific and special repo.<sup>10</sup> Brokerage is paid by both sides to a gilt repo.

The range of participants and end-users has grown as the market has expanded. The overall client base now includes banks, building societies, overseas banks and securities houses, hedge funds, fund managers (such as Standard Life, Scottish Amicable, and so on), insurance companies and overseas central banks. Certain corporates have also begun to undertake gilt repo transactions. The slow start in the use of tri-party repo in the UK market

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<sup>10</sup> Volume discounts are available to customers who transact a large amount of business via brokers. Or, if you see your broker driving down the road in his Bentley, you might want to ask for one!

2  
Screen Printed

DGB 0a Mtge **HBOS**

Page 1 of 1

12:42 GMT

27-Aug-02

REUTERS DEALER CODE HBST											
ELI BILLS			ELI BILLS REPO			STG CDs			GC-CGO		
									BIDS		ISSUE
1M	3.90	-0.00	1W	4.00	-3.85	1M	4.02	-3.92	1M	4.02	-3.92
2M	3.90	-0.00	2W	3.95	-3.80	2M	4.02	-3.92	2M	4.02	-3.92
3M	3.90	-0.00	3W	3.90	-3.80	3M	4.03	-3.93	3M	4.03	-3.93
4M	3.90	-0.00	1M	3.87	-3.77	4M	4.04	-3.94	4M	4.04	-3.94
5M	3.90	-0.00	2M	3.87	-3.77	5M	4.05	-3.95	5M	4.05	-3.95
6M	3.90	-0.00	3M	3.88	-3.78	6M	4.06	-3.96	6M	4.06	-3.96
TREAS BILLS			4M	3.88	-3.78	9M	4.09	-3.99	9M	4.09	-3.99
1M	3.85	-0.00	5M	3.90	-3.80	10	4.13	-4.03	10M	4.13	-4.03
2M	3.85	-0.00	6M	3.92	-3.82	11	4.16	-4.06	11M	4.16	-4.06
3M	3.90	-0.00	9M	3.96	-3.86	1Y	4.19	-4.09	12M	4.19	-4.09
6M	0.00	-0.00	1Y	4.06	-3.96				CMD	6114	
Interbank									Non-Interbank		
020 7256 1030									020 7256 1020		
Refer all rates											

Australia 61 2 9777 8600 Brazil 5511 3048 4500 Europe 44 20 7330 7500 Germany 49 69 920410  
 Hong Kong 852 2977 6000 Japan 81 3 3201 8900 Singapore 65 212 1000 U.S. 1 212 318 2000 Copyright 2002 Bloomberg L.P.  
 6412-52-0 27-Aug-02 14:17:05



Figure 6.12: HBOS plc screen on Bloomberg for 27 August 2002. © HBOS plc © Bloomberg L.P. Reproduced with permission.

has probably constrained certain corporates and smaller financial institutions from entering the market. Tri-party repo would be attractive to such institutions because of the lower administrative burden that comes from having an external custodian. The largest users of gilt repo will remain banks and building societies, who are required to hold gilts as part of their BoE liquidity requirements.

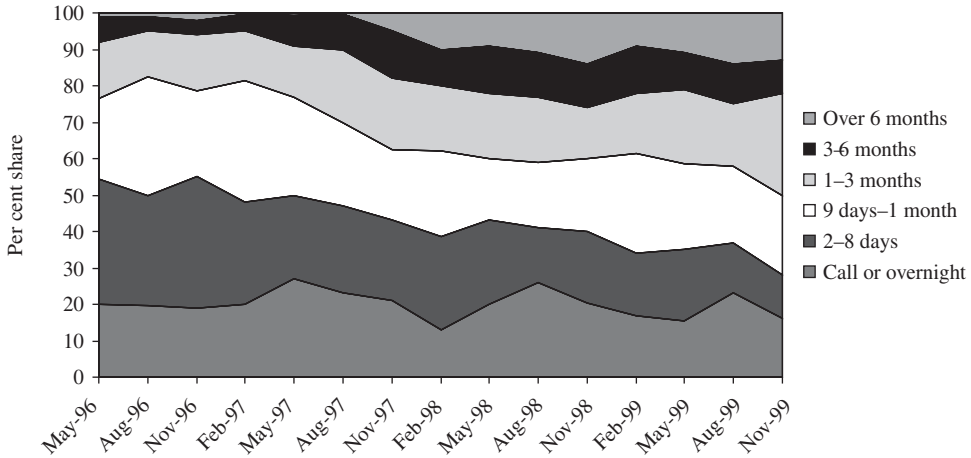
### 6.6.3 Repo market activity

Generally repo trading has been found to be more active when the yield curve is positively sloped, with overnight GC trading at lower rates than 1–2 weeks up to 1 month. This allows the repo trader to enjoy positive funding by borrowing cash overnight on repo while lending funds in the 1 week or 1 month. The trader is of course exposed to unexpected upward movements in overnight rates while covering their positions.

It should be remembered that the short-term money market curve acts independently of the cash gilt curve, especially with regard to long gilt yields, and sometimes has nothing to do with its movements.

Hedging positions in other markets is one of the main motives for some participants' involvement in gilt repo. This is evident in the sterling bond market, where underwriters have benefited from the ability to hedge the interest rate risk on their (long) underwriting positions, by taking an offsetting short position in the gilt they are using to price their bond. This improves the quality of their interest rate hedge. The underwriter uses (reverse) repo to





**Figure 6.13:** Maturity of gilt repo transactions.

(Source: BoE, Quarterly Bulletin, February 2000. Used with permission).

cover the resulting short position in the gilt. Previously underwriters that were not GEMMs would have used less exact hedges such as the long gilt future. The introduction of open repo has therefore benefited the sterling bond market, in that those securities houses issuing sterling bonds can now put on a more effective hedge against their bond position.

Gilt repo activity is concentrated at the very short end of the yield curve, with a majority of deals trading at overnight to one week maturity. This is longer than stock lending, which is generally undertaken overnight or on call. As liquidity has improved, the volume, if not the proportion of longer maturity trades, has increased. Trades of up to three months' maturity are common, and three month repo rates are routinely quoted with a spread of around 5 basis points. Trades of up to 6 months are also not unusual. Figure 6.13 shows the maturity of trades in gilt repo in the three years to November 1999, data reproduced with the permission of the Bank of England.

#### 6.6.4 *Specials trading*

The emergence of *specials* trading is a natural part of a repo market. At the start of the market the BoE stated that one purpose in introducing a repo market was to allow the demand to borrow and lend stocks to be cleared by the price mechanism. Hence it is natural that when stocks are in demand, for example because firms wish to cover short positions arising from underwriting or other reasons, the premium on obtaining them rises. This manifests itself in a reduction in the repo rate for such stocks, as the interest rate payable on cash lent against them decreases compared to the GC rate.

The BoE has conducted a study into the relationship between cash prices and repo rates for stocks that have traded special. This showed a positive correlation between changes in a stock trading expensive to the yield curve and changes in the degree to which it trades special. This is to be expected: traders maintain short positions for paper which has high associated funding costs only if the anticipated fall in the price of the paper is large enough to give a profit. (One implication of this is that longer duration stocks should be less

expensive for a given specials premium, because their prices are more sensitive to changes in yields and therefore a given rise in yields will give a trader running a short position a higher profit to offset any increase in the cost of the repo.)

Both types of cause and effect may be due to the following:

- stock may be perceived as expensive, for example after an *auction* announcement. This creates a greater demand for short positions, and hence greater demand for the paper in repo (to cover short positions);
- at other times stock might go tight in the repo market. It would then tend to be bid higher in the *cash* market as traders closed out existing shorts, which were now too expensive to run; another reason would be that traders and *investors* would try to buy the stock outright since it would now be cheap to finance by repoint out.

There are a number of reasons why a particular stock may go special. Some of these include:

- government bond auctions: when the authorities announce an auction of an existing stock, market makers will run a short position in this stock going into the auction, reflecting institutional investor demand for the issue. This demand may lead to the stock going special;
- outright short selling by proprietary trading desks of banks. In connection with the last point below, this can lead to stocks going special;
- hedging/bond underwriting: for example, a bank that is the underwriter for a Eurobond issue will, unless the issue is 100% successful, have a long position in some of the stock. This will be hedged with the government benchmark security against which the Eurobond is priced; if this is done in sufficient size, the benchmark may go special;
- derivatives trading such as basis trading, resulting in excessive demand for *the cheapest-to-deliver* stock;
- buy back or cancellation of debt: if an issue is bought back, for example by a sovereign government cancellation of some of the nominal outstanding of one of its Brady bonds, there will be a sudden shortage of stock that can lead to special rates and even negative repo rates for this stock;
- small size issues leading to low liquidity: if a particular issue exists only in very small size, it may go special either due to periodic shortages of tradeable stock or as a result of market manipulation creating this shortage. For example, in the gilt market there were a number of esoteric high-coupon bonds, such as the 15% 1997 and others, that existed in sizes of under £1 billion. These stocks periodically experienced special status due to their illiquidity in the secondary market.

Sometimes a combination of these factors can result in a stock going special. In the Japanese government bond markets it is quite common for stock to be special or trade at negative repo rates, as the base interest rates are close to 1%, and have been so for some time now.

The Bank of England has suggested that the link between dearness in the cash market and specialness in the repo market flows both ways: in some cases changes in dearness have preceded changes in specialness and in other cases the sequence has been the other way round. In both cases the stock remains expensive until existing holders take profits by selling their stock or making it available for repo or lending.

An analysis by Garban Europe's gilt repo team (Garban Europe 1998) of the link of the relationship between the specialness of issues and their turnover in the specials market (therefore excluding any GC turnover in the stock) suggested that the level of specialness peaked at around 125 basis points. In other words, special status increased up to a point until cumulative turnover reached around £10 billion, at which point the special spread was 125 basis points, and then declined from this point.

In the gilt strips market<sup>11</sup>, stock is special on an almost permanent basis. This reflects the low volume and liquidity in the cash market in strips, which has struggled to rise above 3% in nominal amount of the conventional market. Only benchmark stocks that are designated as strippable may be stripped. As an example of the special status of these securities, in May 1999 in the stock loan market the 8% Treasury 2021 gilt itself could be borrowed on an open basis (that is, no fixed term) at approximately 10 basis points; the equivalent stock loan fee for the 8% 2021 principal strip was in the range of 50–100 basis points.<sup>12</sup> It is also rare to see repo in coupon strips, reflecting the low volumes of these instruments traded in the cash market.

### **Example 6.1: Market intervention**

On rare occasions the Bank will intervene to relieve excess demand: in November 1996 there was an increase in demand for 7.75% Treasury 2006, mainly because investors switched out of a similar maturity stock as it approached its ex-dividend period. Market makers sold the stock to meet this demand and then simultaneously covered their shorts in the repo market. This sudden demand coupled with the fact that a large amount of this issue was held by investors that did not lend it out led to the special rate trading at close to 0%. The Bank issued £100 million of the stock to help relieve demand.

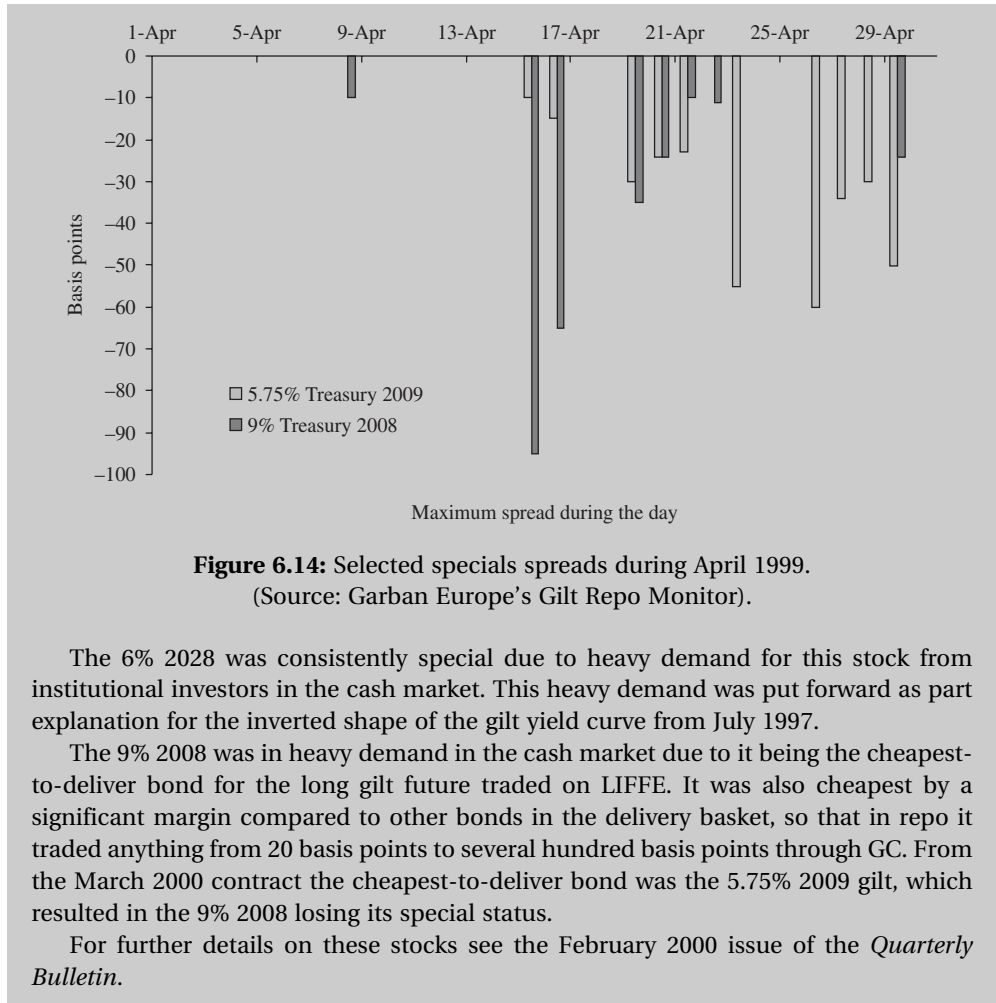
For delivery into the March 1998 LIFFE long gilt futures contract, the BoE made supplies of the cheapest-to-deliver stock (Treasury 9% 2008) available if required, albeit at a rate of 0%! The author is not aware that any market participant made use of this facility.

### **Example 6.2: Specials trading during 1999**

During 1999 three stocks experienced significant special status. The 6% 1999, a stock that matured in August that year, approached a 0% rate and briefly was reported as trading at a negative repo rate. From the start of the repo market it had periodically traded special, which was explained as being a lack of tradeable stock, as it was actually a large size issue with nearly £7 billion nominal outstanding.

<sup>11</sup> Gilt strips are zero-coupon gilts created from "stripping" coupons from conventional gilts, creating a package of single cash flow bonds, in effect zero-coupon bonds, that comprise the individual coupons and the principal repayment of the original ("source") gilt. The market is relatively new, trading having commenced in December 1997. For further information on gilt strips, consult the references in the bibliography.

<sup>12</sup> Thanks to Simon Adams, a former dealing counterparty of mine, and now at RBS Trust Bank, for pointing this out to me.



### 6.6.5 Counterparties

The BoE deals with a wide range of financial institutions active in the gilt repo and/or bill markets, all of whom must satisfy a number of financial criteria, designed to ensure that operations function efficiently and that the liquidity supplied is available to all market participants. Counterparty banks, building societies and securities houses must satisfy the BoE requirements that they:

- have the technical capability to respond quickly and efficiently to the Bank's operations;
- maintain an active presence in the gilt repo and/or bill markets, thus contributing to the distribution of liquidity;
- participate regularly in the Bank's operations; and
- provide the Bank with useful information on market conditions and movements.

There is no formal underwriting commitment, but the BoE monitors compliance with its functional requirements and reserves the right to cease dealing with any counterparty at its own discretion.

## 6.7 Gilt settlement and CREST/CGO

### 6.7.1 Overview

The CREST service is operated by CRESTCo, the body set up to run the London equity market dematerialised settlement system. The Central Gilts Office (CGO), part of the Bank of England, was merged with CREST in July 2000, so that equity, gilt and money market clearing now is conducted through one system.<sup>13</sup> The CGO service was originally established in 1986 by the BoE and the London Stock Exchange to facilitate the settlement of specified securities, essentially gilts and certain sterling bonds such as bulldogs for which the BoE acts as registrar, and was upgraded by the BoE in 1997. In particular the service was upgraded to enhance gilt repo trading activity and to cater for the introduction of the gilt strips facility in December 1997. It also provides a vehicle for the development of real-time delivery-versus-payment (DVP) through links to the Real Time Gross Settlement System (RTGS) for wholesale payments, which was introduced in mid-1996.

The basic concept of the CREST/CGO remains the same as when it was introduced, that is the provision of secure settlement for gilt-edged securities through an efficient and reliable system of electronic book entry transfers in real time against an assured payment. CREST is a real-time, communication-based system. Settlement on the specified business day (T + 1 for normal gilt trades) is dependent on the matching by CREST of correctly input and authenticated instructions by both of the parties and the successful completion of pre-settlement checks on the parties' stock account balances and credit "headroom".

The upgraded CGO provided additional features including:

- greater control by settlement banks over the credit risks run on their customers (by means of a debit-capped payment mechanism);
- the movement of stock free of payment;
- matching of instructions between counterparties;
- a flexible membership structure (allowing the names of "sponsored" as well as "direct" members to appear on the register);
- multiple account designations.

Note that firms must have an account at CREST in order to settle via the system; due to the charges payable for this service many banks opt for an agent settlement bank to handle their transactions. It is now possible to settle gilts through Euroclear and Clearstream Banking, both of which have accounts at CREST.

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<sup>13</sup> A small number of non-British government securities or "bulldogs" did not migrate to the CREST system.

### 6.7.2 *Gilt reference prices*<sup>14</sup>

After a repo trade has been agreed, the back offices of both parties will often use the gilt reference price as the basis for settlement proceeds and other calculations. CREST/CGO uses data supplied by GEMMs for the calculation of these reference prices, which are bid-offer closing prices for each gilt reported to the DMO at the close of business each day. The reference prices for conventional CREST/CGO stocks are based on the clean mid-market closing (normally 4.15pm) prices supplied by members of the GEMM Association. These mid-prices are then adjusted to include accrued interest and quoted to five decimal places, expressed in £100 nominal of stock. Reference prices are updated daily.

Gilt strips trade on a yield basis. The reference price for strips is calculated from gross redemption yields using an “actual/actual” formula, that is, compound interest for all strips divided by the actual number of days in the coupon period.

### 6.7.3 *Delivery-by-value*

*Delivery by Value* (DBV) is a mechanism whereby a CREST member may borrow money from or lend money to another CREST member against overnight gilt collateral. The CREST system automatically selects and delivers securities to a specified aggregate value on the basis of the previous night’s DMO reference prices; equivalent securities are returned the following business day. The DBV functionality allows the giver and taker of collateral to specify the classes of security to be included within the DBV. The options available for DBV stock are:

- all classes of security held within CREST, including strips, index-linked stock and bulldogs;
- coupon-bearing gilts and bulldogs;
- coupon-bearing gilts and strips;
- only coupon-bearing gilts.

DBV repo is a repo transaction in which the delivery of the securities is by the DBV mechanism in CREST; a series of DBV repos may be constructed to form an “open” or “term” DBV repo. The DBV functionality allows repo interest to be automatically calculated and paid.

Note that repo rates can be quoted for “GC” as well as for “DBV”. If we remember that the market convention for both is to bid and offer for nominal amount of stock, this translates into a sum of cash that is the market value of the stock. If we ignore any margin, there is a key difference between the two types of repo: if one deals in GC, the seller of stock must inform the counterparty what specific stock is being passed over within around five minutes of the trade being agreed. In a DBV repo, the seller may deliver any eligible gilt, and this may not be specified up until 3pm on the day of the trade. In this scenario, the repo buyer may not know what stock they are getting until considerably later than the time of trade, only that it will be a CREST/CGO stock. Given that this might conceivably be an index-linked (“I-L”) gilt that is trading at considerably over par, this will impact the amount of cash that will be passed over against the gilt. A party trading DBV repo will accept this situation; however, when trading GC, certain buying parties will specify what stock they are prepared or not prepared to receive, for instance they may state that I-L gilts or strips are not acceptable.

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<sup>14</sup> In the author’s time these were known as CGO reference prices; I have since heard them referred to variously as “DMO reference prices”, “gilt reference prices” and “CREST reference prices”. Take your pick.

A final word on market convention: as repo rates refer to bids and offers for stock, a corporate counterparty that wished to invest a specific amount of cash must clearly state that it has a cash amount to invest. So for example, if we assume that a corporate has £50 million cash to lend, simply lifting a market maker's screen offer in "£50 million GC" may see it receive more (or less) than £50 million-worth of stock, depending on the price of the collateral. Therefore it must clearly state beforehand that it has an exact amount of cash to lend, to avoid confusion.

## 6.8 Repo netting and the LCH RepoClear system

The domestic US dollar repo market has for some time incorporated a *repo netting* facility, operated by the Government Securities Clearing Corporation (GSCC), through which market participants are able to trade in repo with a central counterparty for all their repo requirements, provided all counterparties are also part of the same GSCC service. During 1999 such a facility was introduced in the European market, operated by the London Clearing House and known as *RepoClear*. The principles of RepoClear are very similar to a centralised clearing house function as exists with futures exchanges. The clearing house operates as the counterparty for all market participants, thus eliminating counterparty risk for all trades. As the failure of a market participant would result in liabilities that the clearing house would need to meet, all members of the exchange will deposit an initial margin of cash and/or AAA securities. Depending on the results of their trading, members will also deposit variation margin on an ongoing basis to cover their trading commitments.

RepoClear acts in a similar way. When it began operations, it handled Belgian, Dutch and German government bond repo clearing. During August 2002 the LCH added gilts and gilt repo to the RepoClear facility. This means that for its members, primarily the large investment bank and commercial banking houses, RepoClear acts as the central counterparty for gilt repo transactions, as well as outright gilt purchases. The benefits for the market include:

- balance sheet netting: when a trade is registered with RepoClear and the LCH, an existing bilateral agreement between two counterparties is replaced by two new agreements between LCH and the two counterparties. This results in all exposures being netted multilaterally;
- reduced settlement administration: netting of trades also reduces the number of deliveries, as member banks now have a single settlement per security (with LCH) rather than one with each market counterparty;
- reduction in use of bilateral credit lines: the lending lines used for each repo counterparty are reduced. Previously, a bank would have exposure to each counterparty with whom it traded in gilt repo; under RepoClear this is reduced to one exposure to LCH;
- anonymous repo trading: each member bank deals with LCH, so its trading with the market is now anonymous;

In the first 14 days of the introduction of gilt repo in RepoClear, daily volumes averaged £5.6 billion. Average number of tickets written each day was 120, with the average maturity of each trade at 7.6 days<sup>15</sup>. The Bank of England also reported market participants as saying

<sup>15</sup> Source: Bank of England *Quarterly Bulletin*, Autumn 2002, Volume 42, Number 3.

that gilt repo liquidity had increased at the short end of the yield curve. It also suggested that the benefits of central clearing and netting should include an ability for banks to transact a greater volume of business.

## 6.9 Code of best practice

The *Gilt Repo Code of Best Practice* sets out standards of best practice for gilt repo. It was introduced by the BoE in November 1995 ahead of the commencement of gilt repo trading in January 1996. The Code is set out in various sections, which we summarise below.

### *Preliminary issues*

Market participants should ensure that they have adequate systems and controls for the business they intend to undertake. This includes internal controls, credit risk control systems, written procedures and systems for accounting and taxation.

### *Market professionals*

Before dealing with a client for the first time, market professionals should either confirm that the client is already aware of the Code or draw it to the client's attention.

### *Legal agreement*

Gilt repo transactions should be subject to a legal agreement between the two parties concerned. A market standard is the *Gilt Repo Legal Agreement*, and participants to gilt repo are strongly recommended to adopt this. This agreement is based on the PSA/ISMA Global Master Repurchase Agreement.

### *Margin*

Participants in gilt repo should negotiate suitable initial margin levels, reflecting both their assessment of their counterparty's creditworthiness and the market risks (e.g. duration of collateral) involved in the transaction. Participants should also monitor their net exposure to all counterparties on a daily basis.

### *Custody*

Clients need to ensure that stock loan and repo transactions are identified accordingly to their custodian.

### *Default and close-out*

Once the decision to default has been taken it is important that the process be carried out carefully. This includes the non-defaulting party doing everything in its power to ensure that default market values used in the close-out calculations are fair.

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Fabozzi, F., *Bond Portfolio Management*, 2nd edition, FJF Associates 2001, pages 192, 196, 198.





Nothing lasts forever son.

– Benton Fraser’s father, *Due South* 1997

# 7 The Gilt Bond Basis I

Basis trading, also known as *cash-and-carry* trading, refers to the activity of simultaneously trading cash bonds and the related bond futures contract. An open repo market is essential for the smooth operation of basis trading. Most futures exchanges offer at least one bond futures contract. Major exchanges such as Chicago Board of Trade offer contracts along the entire yield curve; others such as LIFFE provide a market in contracts on bonds denominated in a range of major currencies.

The *basis* of a futures contract is the difference between the spot price of an asset and its price for future delivery as implied by the price of a futures contract written on the asset. Futures contracts are exchange-traded standardised instruments, so they are a form of what is termed a *forward* instrument, a contract that describes the forward delivery of an asset at a price agreed today. The pricing of forwards and futures follows similar principles but, as we shall see, contains significant detail differences between the two. The simultaneous trading of futures contracts written on government bonds and the bonds themselves, basis trading, is an important part of the government bond markets, and in this chapter we review the essential elements of this type of trading. We begin with basis concepts of forward pricing, before looking at the determinants of the basis, hedging using bond futures, trading the basis and an introduction to trading strategy. We also look at the concept of the *cheapest-to-deliver* bond, and the two ways in which this is measured, the net basis and the *implied repo rate*.

## 7.1 An introduction to forward pricing

### 7.1.1 Introduction

We will now look at a more qualitative way of considering the forward bond basis, connected with the coupon and running cost on cash bonds. This approach reads more accessibly for those who wish a more specific application to forward pricing on bond assets.

An investor assessing whether an asset is worth purchasing spot or forward must consider two issues: whether there is an income stream associated with the asset, in which case this would be forgone if the asset was purchased forward; and if there are any holding costs associated with the asset if it is purchased. The forward price on a bond must reflect these same considerations, so a buyer will consider the effect of income forgone and *carry* costs and assess the relative gain of spot versus forward purchase. In real terms then, we are comparing the income stream of the bond coupon against the interest rate on funds borrowed to purchase the bond.<sup>1</sup>

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<sup>1</sup> We assume a leveraged investor: if spot purchase is desired, the investor will borrow the funds used to buy the bond.

An investor who is long a cash bond will receive coupon income, and this is accrued on a daily basis. This is purely an accounting convention and has no bearing to the current interest rate or the current price of the bond.<sup>2</sup> An investor who purchases a bond forward is forgoing the income during the time to delivery, and this factor should presumably be incorporated into the forward price. What of the funding (carry) cost involved? This can be calculated from the current money market rate, provided the term of the funding is known with certainty. So if we now consider a three-month forward contract on a bond against the current spot price of the same bond, the investor must assess:

- the coupon income that would be received during the three-month period;
- the interest charge on funds borrowed during the three-month period.

Let us say that the difference between these two values was exactly 1.00. For the forward contract to be a worthwhile purchase, it would have to be at least 1.00 lower in price than the spot price. This is known as the forward discount. Otherwise the investor is better off buying the bond for spot delivery. However if the price is much lower than 1.00, investors will only buy forward (while cash bondholders would sell their holdings and repurchase forward). This would force the forward price back into line to its *fair value*. The forward price discount is known as the *basis*. The basis exists in all markets where there is a choice available between spot and forward delivery, and not just in financial derivatives. For bonds the basis can be assessed by reference to the current price of the underlying asset, the income stream (coupon), the time to maturity of the forward contract and the current level of interest rates.

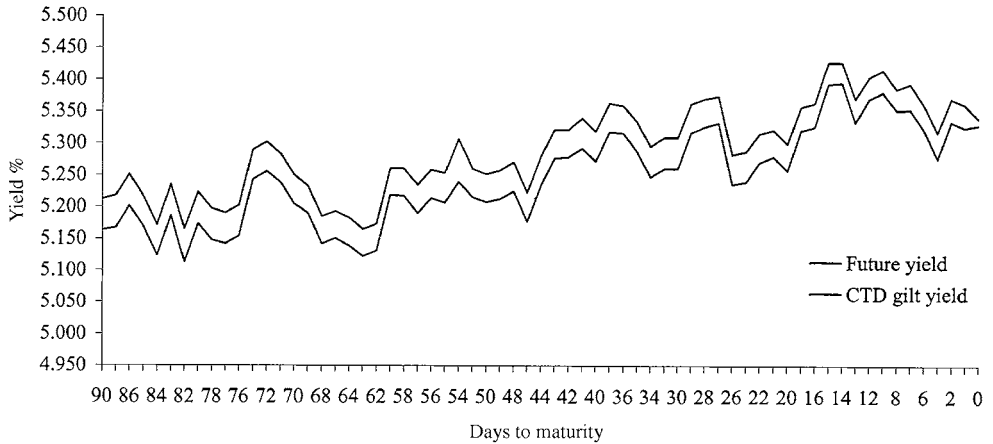
### 7.1.2 *Illustrating the forward bond basis*

Now let us look at an illustration, using the September 2000 long gilt contract. We use the coupon income from the cheapest-to-deliver (CTD) bond, the 5.75% 2009 gilt. However ignore the CTD element for now, and assume a constant money market borrowing rate (repo rate) during the three months of the future from 29 June 2000 to 27 September 2000.

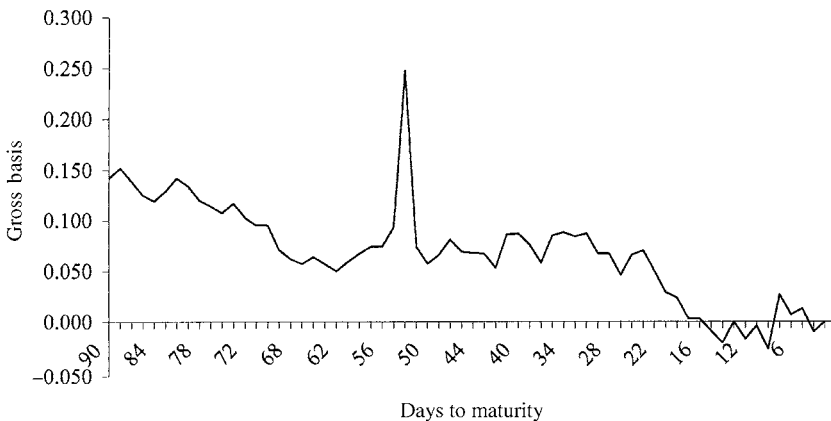
Intuitively we would expect the basis to move towards zero, as the contract approached maturity. After all, what is the price of something for delivery now if not the spot price? First we consider the yield of the bond against the yield of the futures contract. This is illustrated in Figure 7.1. There is slight convergence towards the end. However if we plot the basis itself, this does converge to zero as expected. This is shown as Figure 7.2. As the contract approaches maturity, the basis becomes more and more sensitive to slight changes in bond price or financing rates, hence the exaggerated spike. For instance if short-term repo rates decrease, while the coupon income on the bond remains unchanged, an investor would be faced with a lower level of forgone return as a result of lower financing costs. This makes it

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<sup>2</sup> Van Deventer and Imai (1997) state that the accrued interest concept is “an arbitrary calculation that has no economic meaning”. This is because it reflects the coupon and not current interest rates, so in other words it reflects interest rates at the time of issue. The coupon accrued is identical whatever current interest rates may be. It is worth purchasing this reference as it contains accessible accounts of a number of fixed income analytic techniques.



**Figure 7.1:** Yield of the 5.75% 2009 gilt against the yield of the Sep 00 futures contract. (Source: LIFFE and Bloomberg).



**Figure 7.2:** Gross basis of the Sep 00 futures contract. (Source: LIFFE and Bloomberg).

more attractive for an investor to buy the bond spot delivery, and so the basis will rise as demand for the forward (or future, to be precise) declines.

Essentially when the repo rate is significantly below the bond yield<sup>3</sup>, the basis will be high. If the repo rate then rises the basis will fall, and this indicates the smaller interest rate differential between the repo rate and the bond yield. If the repo rate rises to a point where it is above the bond yield, the basis will turn negative. In fact this occurred briefly during the later stages of the life of the September 2000 gilt future as shown above. A negative basis indicates that the price for forward delivery exceeds that for spot delivery.

<sup>3</sup> The bond's running yield, or flat yield, is usually used.

To reiterate, the forward basis quantifies the relationship between the income generated by the underlying asset and the costs incurred by owning it.<sup>4</sup> As we are concerned with bond futures specifically, the basis will reflect the relationship between the underlying bond's coupon stream and the repo financing rate if holding the bond. Forward contracts for bonds exhibit the basis. Futures contracts, which are standardised forward contracts traded on an organised exchange, are priced on the same principles as forwards and so therefore also exhibit the basis.

## 7.2 The LIFFE long gilt future

### 7.2.1 Introduction

A *futures contract* is an agreement between two counterparties that fixes the terms of an exchange that will take place between them at some future date. They are standardised agreements as opposed to OTC ones, when traded on an exchange, so they are also referred to as *exchange traded futures*. In the UK financial futures are traded on LIFFE, which opened in 1982. LIFFE is the biggest financial futures exchange in Europe in terms of volume of contracts traded. There are four classes of contract traded on LIFFE: short-term interest rate contracts, long-term interest rate contracts (bond futures), currency contracts and stock index contracts.

In this section we will look at bond futures contracts, which are an important part of the bond markets; they are used for hedging and speculative purposes. Most futures contracts on exchanges around the world trade at three-month maturity intervals, with maturity dates fixed at March, June, September and December each year. This includes the contracts traded on LIFFE. Therefore at pre-set times during the year a contract for each of these months will *expire*, and a final *settlement* price is determined for it. The further out one goes the less liquid the trading is in that contract. It is normal to see liquid trading only in the *front month* contract (the current contract, so that if we are trading in April 2000 the front month is the June 2000 future), and possibly one or two of the next contracts, for most bond futures contracts. The liquidity of contracts diminishes the further one trades out in the maturity range.

When a party establishes a position in a futures contract, it can either run this position to maturity or close out the position between trade date and maturity. If a position is closed out the party will have either a profit or loss to book. If a position is held until maturity, the party who is long the future will take delivery of the underlying asset (bond) at the settlement price; the party who is short futures will deliver the underlying asset. This is referred to as *physical settlement* or sometimes, confusingly, as *cash settlement*.

There is no counterparty risk associated with trading exchange-traded futures, because of the role of the *clearing house*, such as the London Clearing House (LCH). This is the body through which contracts are settled. A clearing house acts as the buyer to all contracts sold on the exchange, and the seller to all contracts that are bought. So in the London market the LCH acts as the counterparty to all transactions, so that settlement is effectively guaranteed. The LCH requires all exchange participants to deposit *margin* with it, a cash sum that is the cost of conducting business (plus brokers' commissions). The size of the margin depends on the size of a party's net *open* position in contracts (an open position is a position in a contract that is held overnight and not closed out). There are two types of margin, *main-*

<sup>4</sup> Readers are invited to think of assets for which the forward basis is routinely negative ...

*tenance margin* and *variation margin*. Maintenance margin is the minimum level required to be held at the clearing house; the level is set by the exchange. Variation margin is the additional amount that must be deposited to cover any trading losses and as the size of the net open positions increases. Note that this is not like margin in say, a repo transaction. Margin in repo is a safeguard against a drop in value of collateral that has been supplied against a loan of cash. The margin deposited at a futures exchange clearing house acts essentially as “good faith” funds, required to provide comfort to the exchange that the futures trader is able to satisfy the obligations of the futures contract being traded.

### 7.2.2 Bond futures contracts

We have noted that futures contracts traded on an exchange are standardised. This means that each contract represents exactly the same commodity, and it cannot be tailored to meet individual customer requirements.

A futures contract specifies a notional coupon to prevent delivery and liquidity problems that would arise if there was shortage of bonds with exactly the coupon required, or if one market participant purchased a large proportion of all the bonds in issue with the required coupon. For exchange traded futures, a short future can deliver any bond that fits the maturity criteria specified in the contract terms. Of course a long future would like to be delivered a high-coupon bond with significant accrued interest, while the short future would want to deliver a low-coupon bond with low interest accrued. In fact this issue does not arise because of the way the *invoice amount* (the amount paid by the long future to purchase the bond) is calculated. The invoice amount on the expiry date is given at (7.1):

$$Inv_{amt} = P_{fut} \times CF + AI \quad (7.1)$$

where

$Inv_{amt}$	is the invoice amount
$P_{fut}$	is the price of the futures contract
$CF$	is the conversion factor
$AI$	is the bond accrued interest.

#### Invoice amount

When the bond is delivered, the long pays the short an invoice amount:

$$Invoiced = [EDSP/100 \times CF \times Nominal] + AI$$

The settlement price (or *exchange delivery settlement price*, EDSP) is the trading price per £100 nominal for the futures contract on the last day of trading, and is confirmed by the exchange. The invoice amount includes accrued interest because the futures contract is traded at a *clean* price and does not include accrued interest.

Any bond that meets the maturity specifications of the futures contract is said to be in the *delivery basket*, the group of bonds that are eligible to be delivered into the futures contract. Every bond in the delivery basket will have its own *conversion factor*, which is used to equalise coupon and accrued interest differences of all the delivery bonds. The exchange

will announce the conversion factor for each bond before trading in a contract begins; the conversion factor for a bond will change over time, but remains fixed for one individual contract. That is, if a bond has a conversion factor of 1.091252, this will remain fixed for the life of the contract. If a contract specifies a bond with a notional coupon of 7%, like the long gilt future on LIFFE, then the conversion factor will be less than 1.0 for bonds with a coupon lower than 7% and higher than 1.0 for bonds with a coupon higher than 7%. A formal definition of conversion factor is given below.

### Conversion factor

The conversion factor (or price factor) gives the price of an individual cash bond such that its yield to maturity on the delivery day of the futures contract is equal to the notional coupon of the contract. The product of the conversion factor and the futures price is the forward price available in the futures market for that cash bond (plus the cost of funding, referred to as the gross basis).

Although conversion factors equalise the yield on bonds, bonds in the delivery basket will trade at different yields, and for this reason they are not “equal” at the time of delivery. Certain bonds will be cheaper than others, and one bond will be the *cheapest-to-deliver* bond. The cheapest-to-deliver bond is the one that gives the greatest return from a strategy of buying a bond and simultaneously selling the futures contract, and then closing out positions on the expiry of the contract. This cash-and-carry trading is actively pursued by proprietary trading desks in banks. If a contract is purchased and then held to maturity the buyer will receive, via the exchange’s clearing house the cheapest-to-deliver gilt. The mathematical calculation of the conversion factor for the gilt future is given at Appendix 7.1.

We summarise the contract specification of the long gilt futures contract traded on LIFFE at Table 7.1. There is also a medium gilt contract on LIFFE, which was introduced in

#### LIFFE long gilt contract

Unit of trading	UK gilt bond having a face value of £100,000, a notional coupon of 7% and a notional maturity of 10 years, changed from contract value of £50,000 from the September 1998 contract
Deliverable grades	UK gilts with a maturity ranging from 8¾ to 13 years from the first day of the delivery month (changed from 10–15 years from the December 1998 contract)
Delivery months	March, June, September, December
Delivery date	Any business day during the delivery month
Last trading day	11:00 hours two business days before last business day of delivery month
Quotation	Per cent of par expressed as points and hundredths of a point, for example 114.56 (changed from ticks and 1/32nds of a point, as in 114–17 meaning 114 17/32 or 114.53125, from the June 1998 contract)
Minimum price movement	0.01 of one point (one tick)
Tick value	£10
Trading hours	08:00–18:00 hours All trading conducted electronically on LIFFE CONNECT™ platform

**Table 7.1:** LIFFE long gilt future contract specification. (Source: LIFFE).

1998 (having been discontinued in the early 1990s). This trades a notional five-year gilt, with eligible gilts being those of 4 to 7 years' maturity.

## 7.3 Futures pricing

### 7.3.1 *The theoretical principle*

Although it may not appear so on first sight, floor trading on a futures exchange is probably the closest one gets to an example of the economist's perfect and efficient market. The immediacy and liquidity of the market will ensure that at virtually all times the price of any futures contract reflects fair value. In essence because a financial futures contract represents an underlying asset, albeit a synthetic one, its price cannot differ from the actual cash market price of the asset itself. This is because the market sets futures prices such that they are arbitrage-free. We can illustrate this with a hypothetical example.

Let us say that the benchmark 10-year bond, with a coupon of 8% is trading at par. This bond is the underlying asset represented by the long bond futures contract; the front month contract expires in precisely three months. If we also say that the three-month Libor rate (the repo rate) is 6%, what is fair value for the front month futures contract?

For the purpose of illustration let us start by assuming the futures price to be 105. We could carry out the following arbitrage-type trade:

- buy the bond for £100;
- simultaneously sell the future at £105;
- borrow £100 for three months at the repo rate of 6%.

As this is a leveraged trade we have borrowed the funds with which to buy the bond, and the loan is fixed at three months because we will hold the position to the futures contract expiry, which is in exactly three months' time. At expiry, as we are short futures we will deliver the underlying bond to the futures clearing house and close out the loan. This strategy will result in cash flows for us as shown below.

#### *Futures settlement cash flows*

Price received for bond	= 105.00
Bond accrued	= 2.00 (8% coupon for three months)
Total proceeds	= 107.00

#### *Loan cash flows*

Repayment of principal	= 100.00
Loan interest	= 1.500 (6% repo rate for three months)
Total outlay	= 101.50

The trade has resulted in a profit of £5.50, and this profit is guaranteed as we have traded the two positions simultaneously and held them both to maturity. We are not affected by subsequent market movements. The trade is an example of a pure arbitrage, which is risk-free. There is no cash outflow at the start of the trade because we borrowed the funds used to buy the bond. In essence we have locked in the forward price of the bond by trading the



future today, so that the final settlement price of the futures contract is irrelevant. If the situation described above were to occur in practice it would be very short-lived, precisely because arbitrageurs would buy the bond and sell the future to make this profit. This activity would force changes in the prices of both bond and future until the profit opportunity was removed.

So in our illustration the price of the future was too high (and possibly the price of the bond was too low as well) and not reflecting fair value because the price of the synthetic asset was out of line with the cash asset.

What if the price of the future was too low? Let us imagine that the futures contract is trading at 95.00. We could then carry out the following trade:

- sell the bond at £100;
- simultaneously buy the future for £95;
- lend the proceeds of the short sale (£100) for three months at 6%.

This trade has the same procedure as the first one with no initial cash outflow, except that we have to cover the short position in the repo market, through which we invest the sale proceeds at the repo rate of 6%. After three months we are delivered a bond as part of the futures settlement, and this is used to close out our short position. How has our strategy performed?

*Futures settlement cash flows*

Clean price of bond	= 95.00
Bond accrued	= 2.00
Total cash outflow	= 97.00

*Loan cash flows*

Principal on loan maturity	= 100.00
Interest from loan	= 1.500
Total cash inflow	= 101.50

The profit of £4.50 is again a risk-free arbitrage profit. Of course our hypothetical world has ignored considerations such as bid-offer spreads for the bond, future and repo rates, which would apply in the real world and impact on any trading strategy. Yet again, however, the futures price is out of line with the cash market and has provided opportunity for arbitrage profit.

Given the terms and conditions that apply in our example, there is one price for the futures contract at which no arbitrage profit opportunity is available. If we set the future price at 99.5, we would see that both trading strategies, buying the bond and selling the future or selling the bond and buying the future, yield a net cash flow of zero. There is no profit to be made from either strategy. So at 99.5 the futures price is in line with the cash market, and it will only move as the cash market price moves; any other price will result in an arbitrage profit opportunity.

### **7.3.2 Arbitrage-free futures pricing**

The previous section demonstrated how we can arrive at the fair value for a bond futures contract provided we have certain market information. The market mechanism and continuous

trading will ensure that the fair price *is* achieved, as arbitrage profit opportunities are eliminated. We can determine the bond future's price given:

- the coupon of the underlying bond, and its price in the cash market;
- the interest rate for borrowing or lending funds, from the trade date to the maturity date of the futures contract. This is known as the *repo* rate.

For the purpose of deriving this pricing model we can ignore bid-offer spreads and borrowing and lending spreads. We set the following:

$r$	is the repo rate
$rc$	is the bond's running yield
$P_{bond}$	is the price of the cash bond
$P_{fut}$	is the price of the futures contract
$t$	is the time to the expiry of the futures contract.

We can substitute these symbols into the cash flow profile for our earlier trade strategy, that of buying the bond and selling the future. This gives us:

<i>Futures settlement cash flows</i>	
Clean price for bond	$= P_{fut}$
Bond accrued	$= rc \cdot t \cdot P_{bond}$
Total proceeds	$= P_{fut} + (rc \cdot t \cdot P_{bond})$
<i>Loan cash flows</i>	
Repayment of loan principal	$= P_{bond}$
Loan interest	$= r \cdot t \cdot P_{bond}$
Total outlay	$= P_{bond} + (r \cdot t \cdot P_{bond})$

The profit from the trade would be the difference between the proceeds and outlay, which we can set as follows:

$$\text{Profit} = P_{fut} + rc \cdot t \cdot P_{bond} - (P_{bond} + r \cdot t \cdot P_{bond}).$$

We have seen how the futures price is at fair value when there is no profit to be gained from carrying out this trade, so if we set profit at zero, we obtain the following:

$$0 = P_{fut} + rc \cdot t \cdot P_{bond} - (P_{bond} + r \cdot t \cdot P_{bond}).$$

Solving this expression for the futures price  $P_{fut}$  gives us:

$$P_{fut} = P_{bond} + P_{bond}t(r - rc).$$

Rearranging this we get:

$$P_{fut} = P_{bond}(1 + t(r - rc)) \tag{7.2}$$

If we repeat the procedure for the other strategy, that of selling the bond and simultaneously buying the future, and set the profit to zero, we will obtain the same expression for the futures price as given in (7.2) above.

It is the level of the repo rate in the market, compared to the running yield on the underlying bond, that sets the price for the futures contract. From the examples used at the start of this section we can see that it is the cost of funding compared to the repo rate that determines if the trade strategy results in a profit. The expression  $(r - rc)$  from (7.2) is the net financing cost in the

arbitrage trade, and is known as the *cost of carry*. If the running yield on the bond is higher than the funding cost (the repo rate) this is positive funding or *positive carry*. Negative funding (*negative carry*) is when the repo rate is higher than the running yield. The level of  $(r - rc)$  will determine whether the futures price is trading above the cash market price or below it. If we have positive carry (when  $rc > r$ ) then the futures price will trade below the cash market price, known as trading at a *discount*. Where  $r > rc$  and we have negative carry then the futures price will be at a premium over the cash market price. If the net funding cost was zero, such that we had neither positive or negative carry, then the futures price would be equal to the underlying bond price.

The cost of carry related to a bond futures contract is a function of the yield curve. In a positive yield curve environment the three-month repo rate is likely to be lower than the running yield on a bond so that the cost of carry is likely to be positive. As there is generally only a liquid market in long bond futures out to contracts that mature up to one year from the trade date, with a positive yield curve it would be unusual to have a short-term repo rate higher than the running yield on the long bond. So in such an environment we would have the future trading at a discount to the underlying cash bond. If there is a negative sloping yield curve the futures price will trade at a premium to the cash price. It is in circumstances of changes in the shape of the yield curve that opportunities for relative value and arbitrage trading arise, especially as the bond that is cheapest-to-deliver for the futures contract may change with large changes in the curve.

A trading strategy that involved simultaneous and opposite positions in the cheapest-to-deliver bond (CTD) and the futures contract is known as *cash-and-carry* trading or *basis trading*. However, by the law of no-arbitrage pricing, the payoff from such a trading strategy should be zero. If we set the profit from such a trading strategy as zero, we can obtain a pricing formula for the fair value of a futures contract, which summarises the discussion above, and states that the fair value futures price is a function of the cost of carry on the underlying bond. This is given at (7.3):

$$P_{fut} = \frac{(P_{bond} + AI_0) \times (1 + rt) - \sum_{i=1}^N C_i(1 + rt_{i,del}) - AI_{del}}{CF} \quad (7.3)$$

where

$AI_0$	is the accrued interest on the underlying bond today
$AI_{del}$	is the accrued interest on the underlying bond on the expiry or delivery date (assuming the bond is delivered on the final day, which will be the case if the running yield on the bond is above the money market rate)
$C_i$	is the $i$ th coupon
$N$	is the number of coupons paid from today to the expiry or delivery date
$r$	is the repo rate
$t$	is the time period (in years) over which the trade takes place
$CF$	is the bond conversion factor
$t_{i,del}$	is the period from receipt of $i$ th coupon to delivery.

## 7.4 The bond basis: basic concepts

### 7.4.1 Introduction

The previous section introduced the no-arbitrage forward pricing principle and the concept of the basis. We will look at this again later. So we know that the price of an asset, including

a bond, that is agreed today for immediate delivery is known as its *spot* price.<sup>5</sup> In essence the forward price of an asset, agreed today for delivery at some specified future date, is based on the spot price and the cost or income of forgoing delivery until the future date. If an asset carries an income stream, withholding delivery until say, three months in the future would present an opportunity cost to an investor in the asset, so the prospective investor would require a discount on the spot price as the price of dealing in a forward. However if an asset comes with a holding cost, for example storage costs, then an investor would expect to pay a premium on the spot price, as they would not be incurring the holding costs that are otherwise associated with the asset.

Commodities such as wheat or petroleum are good examples of assets whose forward delivery is associated with a holding cost. For a commodity whose price is agreed today but for which delivery is taken at a forward date, economic logic dictates that the futures price must exceed the spot price. That is, a commodity basis is usually negative. Financial assets such as bonds have zero storage costs, as they are held in electronic form in a clearing system such as Euroclear or CREST/CGO; moreover they provide an income stream that would offset the cost of financing a bondholding until a future date. Under most circumstances when the yield curve is positively sloping, the holding of a bond position until delivery at a future date will generate a net income to the holder. For these and other reasons it is common for the bond basis to be positive, as the futures price is usually below the spot price.

As we shall see shortly, bond futures contracts do not specify a particular bond, rather a generic or *notional* bond. The actual bond that is delivered against an expired futures contract is the one that makes the cost of delivering it as low as possible, that is, the cheapest-to-deliver. Considerable research has been undertaken into the concept of the cheapest-to-deliver (CTD) bond. In fact, certain commodity contracts also trade with an underlying CTD. Burghardt (1994) points out that wheat is not a homogenous product, as wheat from one part of the country exhibits different characteristics to wheat from another part of the country, and may have to be transported a longer distance (hence at greater cost) to delivery. Therefore a wheat contract is also priced based on the designated cheapest-to-deliver. There is no physical location factor with government bonds, but futures contracts specify that any bond may be delivered that falls into the required maturity period.

In this section we look at the basic concepts, necessary for an understanding of the bond basis, and introduce all the key topics. Basis trading itself is the simultaneous trading of cash bond and the bond futures contract, an arbitrage trade that seeks to exploit any mispricing of the future against the cash or vice versa.<sup>6</sup> In liquid and transparent markets such mispricing is rare, of small magnitude and very short-lived. The arbitrageur will therefore also try to make a gain from the difference between the costs of holding (or shorting) a bond against that of delivering (or taking delivery of) it at the futures expiry date; essentially then, the difference between the bond's running yield and its repo financing cost.

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<sup>5</sup> We use the term "immediate" delivery although for operational, administrative and settlement reasons actual delivery may be a short period in the future, say anything up to several days or even longer.

<sup>6</sup> Another term for basis trading is *cash-and-carry* trading. The terms are used interchangeably.

### 7.4.2 The conversion factor

So, we know that a bond futures contract represents any bond whose maturity date falls in the period described in the contract specifications. During the delivery month, and up to the expiry date, the party that is short the future has the option on which bond to deliver and on what day in the month to deliver it. Let us consider the long gilt contract on LIFFE. If we assume the person that is short the future delivers on the expiry date, for each contract they must deliver to the exchange's clearing house<sup>7</sup> £100,000 nominal of a notional 7% gilt of between 8<sup>3</sup>/<sub>4</sub> and 13 years' maturity. Of course no such specific bond exists, so the seller delivers a bond from within the delivery basket. However, if the seller delivers a bond of say, 6% coupon and 9 years' maturity, intuitively we see that the value of this bond is lower than a 7% bond of 13 years' maturity. While the short future may well think, "fine by me", the long future will most certainly think not. There would be the same aggrieved feelings, just reversed, if the seller was required to deliver a bond of 8% coupon. To equalise all bonds, irrespective of which actual bond is delivered, the futures exchange assigns a *conversion factor* to each bond in the delivery basket. This serves to make the delivery acceptable to both parties. Conversion factors are used in the invoice process to calculate the value of the delivered bond that is equal to that specified by the contract. In some texts the conversion factor is known as the *price factor*. The concept of the conversion factor was developed by CBOT in the 1970s.

Table 7.2 shows the conversion factors for all gilts that were eligible for delivery as of 30 August 2001 for the September 2001 to September 2002 contracts. Notice how the conversion factors exhibit the "pull to par", decreasing towards 1.00 for those with a coupon above the notional 7% and increasing towards 1.00 for bonds with a coupon below 7%. The passage of time also shows bonds falling out of the delivery basket, and the introduction of a new issue into the basket, the 5% gilt maturing 7 March 2012.

The yield obtainable on bonds that have different coupons but identical maturities can be equalised by adjusting the price for each bond. This principle is used to calculate the conversion factors for different bonds. The conversion factor for a bond is the price per £1 (or per \$1, €1, and so on) at which the bond would give a yield equal to the yield of the notional coupon specified in the futures contract. This is 7% in the case of the long gilt contract, 6% for the Treasury long bond, and so on. In other words the conversion factor for

Gilt	Contract					
	Dec 00	Mar 01	Jun 01	Sep 01	Dec 01	Mar 02
5.75% Treasury 2009	0.9174728	0.9189802				
6.25% Treasury 2010	0.9467478	0.9475611	0.9486415	0.9494956	0.9505874	
9% Conversion 2011	1.1479281	1.1455578	1.1431026	1.1405936	1.1381240	1.1355859
5% Treasury 2012				0.8528791	0.8551727	0.8577270
9% Treasury 2012	1.1576368	1.1555512	1.1531626			
8% Treasury 2013	1.0835676	1.0826206	1.0814990	1.0805114	1.0793560	1.0783363

**Table 7.2:** Conversion factors for deliverable gilts, Dec00 to Mar02 long gilt contracts. (Source: LIFFE).

<sup>7</sup> In our example, to the London Clearing House. The LCH then on-delivers to the party that is long the contract. The long pays the settlement invoice price.

each bond is the price such that every bond would provide an investor with the same yield if purchased; or, the price at which a deliverable bond would trade if its gross redemption yield was 7% (or 6%, and so on). The yield calculation is rounded to whole quarters, given the delivery month cycle of futures. Futures exchanges calculate conversion factors effective either on the exact delivery date, where a single date is defined, or (as at LIFFE) on the first day of the delivery month if delivery can take place at any time during the delivery month.

The conversion factor is assigned by the exchange to each bond in the delivery basket at the start of trading of each contract. It remains constant throughout the life of the contract. A particular bond that remains in the delivery basket over a length of time will have different conversion factors for successive contracts. For example the 9% UK Treasury maturing on 13 October 2008 had conversion factors of 1.1454317, 1.1429955 and 1.1407155 for the LIFFE long gilt contracts that matured in June, September and December 1998 respectively.

Other things being equal, bonds with a higher coupon will have larger conversion factors than those with lower coupons. For bonds with the same coupon, maturity has an influence, though this is slightly less obvious. For bonds with coupons below the notional rate defined in the contract description, the conversion factor is smaller for bonds with a longer maturity. The opposite is true for bonds carrying coupons in excess of the notional coupon rate, for which the conversion factor will be larger the longer the maturity. This effect arises from the mathematics of fixed-interest securities. Bonds with coupon below current market yields will trade at a discount. This discount is larger the longer the maturity, because it is a disadvantage to hold a bond paying a coupon lower than current market rates, and this disadvantage is greater the longer the period to the bond maturing. Conversely bonds with coupons above current market yields trade at a premium which will be greater the longer the maturity.

To help calculate the *invoice price* of a bond on delivery, we multiply the price of the final settlement price of the futures contract with its conversion factor. This gives us the *converted price*. The price payable by the long future on delivery of the bond is the invoice price, and this is the futures settlement price plus accrued interest. This was shown in simple fashion as equation (7.1). The actual invoice price, calculated once the actual bond being delivered is known, is given by:

$$P_{Inv} = (M_{fut} \times P_{futsett} \times CF) + AI \quad (7.4)$$

where

$P_{Inv}$	is the invoice price
$M_{fut}$	is the nominal value of the delivered bonds as specified in the contract
$P_{futsett}$	is the futures settlement price.

### Example 7.1: Calculating the invoice price

A futures contract settles at 102.50. The contract specifies £100,000 nominal of the underlying bond. The delivered bond has a conversion factor of 1.14579 and accrued interest of 0.73973. The settlement price is equal to 1.025% of the nominal value (par value). The invoice price is calculated as:

$$\begin{aligned} P_{Inv} &= (100,000 \times 1.025 \times 1.14579) + 0.73973 \\ &= \pounds 117,443 + 0.73973 \end{aligned}$$

The LIFFE conversion factor for the long gilt is reproduced at Appendix 7.1. It is worth summarising what we know so far about conversion factors:

- conversion factors remain constant for a bond from the moment they are assigned to the expiry of the contract;
- conversion factors are different for each bond and for each contract;<sup>8</sup> from Table 7.2, which relates to the long gilt contract and its notional coupon of 7%, we see that conversion factors for bonds with coupons higher than 7% diminish in value for each successive contract month, while those for bonds with coupons lower than 7% rise in value for successive contract months. This reflects the “pull to par” effect, which for bonds with the higher coupon is falling from a premium and for bonds with the lower coupon is rising from a discount;
- the conversion factor is used to calculate the invoice price of a bond that is delivered into a futures contract;
- bonds with coupons greater than the notional coupon of the futures contract have a conversion factor higher than 1, while bonds with coupons lower than the notional coupon have a conversion factor lower than 1.

The conversion factor is not a hedge ratio, as has been strongly emphasised by both Burghardt and Galitz<sup>9</sup>, and should not be used as such.

Using conversion factors provides an effective system for making all deliverable bonds perfect substitutes for one another. The system is not perfect of course. Conversion factors are calculated to equalise returns at a single uniform yield, the notional coupon rate specified in the contract specification. In practice though, bonds trade at different yields, resulting in the yield curve. Hence despite the use of conversion factors, bonds will not be precisely “equal” at the time of delivery. Some bonds will be relatively more expensive, some cheaper; one particular bond will be the *cheapest-to-deliver* bond. The cheapest-to-deliver (CTD) bond is an important concept in the pricing of bond futures contracts.

### 7.4.3 *The bond basis*

Basis trading arises from the difference between the current clean price of a bond and the (implied) forward clean price at which the bond is bought through the purchase of a futures contract. The difference between these two prices is known as the *gross basis*. This is the bond basis to which the market refers, the difference between the bond’s spot cash price and the price implied by the current price of the futures contract. The latter is given by multiplying the futures price by the relevant bond’s conversion factor.

The formula for calculating the gross basis is therefore:

$$Basis = P_{bond} - (P_{fut} \times CF) \quad (7.5)$$

<sup>8</sup> If two bonds had identical coupons and maturity dates, then they would have the same conversion factor for a specific contract. However under these terms the two bonds would be identical as well...

<sup>9</sup> Burghardt (*ibid*), page 9 and chapter 5; Galitz (1995), page 398.

From (7.5) we might think that if we sell a futures contract short, in effect this guarantees an ability to deliver the bond at the futures delivery date and receive a known price for the bond. However the price payable for the bond at delivery is based on the future's final settlement price, and not the trading price of the future at any time beforehand, and so this thinking is erroneous.

In the Treasury market both cash and futures prices are quoted as points and ticks (32nds) per \$100 nominal value, and if necessary as half-ticks or 64ths. A 64th price is indicated by a +.

The gross basis can be explained as the difference between the running yield on the bond and the current repo (money market) rate. However, a residual factor exists due to the delivery option implicit in the design of the futures contract and to the daily marking-to-market of the contract, both of which are more difficult to quantify. This residual amount is known as the *net basis*. Net basis is the gross basis adjusted for net carry. Net carry is the actual coupon income and re-investment less borrowing expense, which is at the security's actual repo or money market financing rate.

Figure 7.3 is the Bloomberg page DLV of the deliverable bonds for the June 2000 long gilt contract, and shows the conversion factors and gross basis value for each bond in the basket.

<HELP> for explanation, <MENU> for similar functions. P140 Comdty DLV  
 Hit (NUMBER) <GO> to view Historical Basis/Repo

**Cheapest to Deliver** Trade 8/27/02 Dlv 9/30/02  
 LONG GILT FUTURE Sep02 G U2 114.95 Set 8/28/02 Cheapest IRP= 3.46

Order	DR	re-sort	Price	Source	Yield	C.Factor	Gross Basis	33 Days Act/365		DECIMAL Net Basis	
								Implied Repo%	Actual Repo%		
MASTER:											
1)	UKT	9	07/12/11	130.3200	BGN	4.768	1.1302684	3.96	3.46	4.01	.065
2)	UKT	5	03/07/12	102.0700	BGN	4.727	.8627494	2.897	-26.32	4.01	2.816
3)	UKT	8	09/27/13	127.8100	BGN	4.744	1.0760768	4.115	-28.72	4.01	3.870
4)	UKT	5	09/07/14	102.3100	BGN	4.746	.8392904	5.834	-58.14	4.01	5.751

Australia 61 2 9777 8600 Brazil 5511 3048 4500 Europe 44 20 7330 7500 Germany 49 69 920410  
 Hong Kong 852 2977 6000 Japan 81 3 3201 8900 Singapore 65 212 1000 U.S. 1 212 318 2000 Copyright 2002 Bloomberg L.P.  
 G412-52-0 27-Aug-02 14:17:26



**Figure 7.3:** Delivery basket for September 02 long gilt, Bloomberg page DLV, 27 August 2002. © Bloomberg L.P. Reproduced with permission.



**Example 7.2: The gross basis**

Consider the following market details, all relating to one instantaneous point in time:

Settlement date	16 March 2000
Futures delivery date	30 June 2000
Days to delivery	106
Bond price (UKT 9% 2011)	131.4610
Accrued interest	1.5780822
Accrued to delivery	4.1917808
Futures price (M0 LIFFE Long gilt)	112.98
Conversion factor	1.1525705
Cash market repo rate	6.24%

We can calculate the gross basis that would apply in a hypothetical cash-and-carry trade, where there is a simultaneous purchase of the bond and sale of the futures contract as shown below.

bond purchase – outflow of funds:  $131.461 + 1.5781 = 133.0390822$

futures sales – inflow of funds:  $(112.98 \times 1.1525705) + 4.192 = 134.409196$ .

The gross basis is  $131.4610 - (112.98 \times 1.1525705)$  or 1.24358491.

**7.4.4 The net basis**

We've seen from the previous section that gross basis measures the carry on a bond that applies during the life of the futures contract. Because of other factors associated with the delivery into a futures contract, principally that delivery is at the option of the short future, the gross basis is not the actual carry that would be incurred if a trader put on a cash versus futures trade. This is measured by the *net basis*. The net basis causes much confusion amongst market participants, but it is a straightforward concept. Burghardt states that the net basis is the difference between a bond's basis and its total carry to delivery.<sup>10</sup> Plona describes net basis as the difference between the *implied repo rate* and the general collateral repo rate. We consider the implied repo rate (IRR) in Section 7.4.5.<sup>11</sup>

Both descriptions are good ways in which to consider net basis. Essentially the net basis is the gross basis adjusted for net carry. Net carry is the actual coupon income (and any reinvestment income) minus borrowing expense, which is at the security's actual repo (money market) rate. The net basis is therefore the true "economic basis" and measures the net gain from a simultaneous position in the cash bond and the futures contract. A positive value represents a *loss* or net cost to the long cash/short futures position, and the net basis is the expected *profit* for the short cash/long futures position (where the actual repo rate used is the reverse repo rate). The opposite is true for negative net basis values.

<sup>10</sup> *Ibid*, page 33. It is also known as the *basis net of carry*.

<sup>11</sup> Plona (or *Ibid*), page 32.

The net basis is calculated on the assumption that a basis trade is conducted by the arbitrageur borrowing funds to purchase the cheapest-to-deliver bond, financing it in the repo market, and shorting the futures contract. It measures the maximum *loss* that would be suffered by holding this position until the contract expiry date. The net basis should be negative as a loss measure; a positive net basis indicates the potential profit from such a trade.<sup>12</sup> On the other hand, a negative net basis theoretically indicates the potential profit from a short bond/long futures position.

To calculate the net basis, we need to make an assumption about the financing rates that would apply to a basis trade.<sup>13</sup> This centres on the repo rate that is applicable to the cash bond element of the trade. Analysts use one of two methods:

- using the specific repo rate for the cash bond, fixed to the maturity date. This is a logical approach, as it provides an accurate measure of the financing cost associated with running a long position in the bond, and then delivering it into the futures exchange. Calculating net basis under this method provides a measure of the value of the delivery option;
- using the overnight GC repo rate, assuming therefore that the bond position is financed on a daily basis. However, assuming that the overnight rate will be maintained more or less over the term of the trade is risky.

#### 7.4.5 *The implied repo rate*

In a basis trade the rate implied by the strategy is known as a repo rate because it is equivalent to a *repurchase* agreement with the futures market. In effect the short future lends money to the futures market: the short future agrees to buy a bond with a simultaneous provision to sell it back to the market at a pre-determined price and to receive a rate of interest on their money, the repo rate. It is the *implied repo rate* because it is an expected repo rate gain if the trade was carried out. In some literature it is suggested as a complex and obscure calculation, in fact the implied repo rate (IRR) is very straightforward to calculate. It is the theoretical return from a basis trade of long cash bond against short future, with the bond delivered into the future on expiry.

The IRR is a measure of return from a basis trade. Consider the cash flows involved when one is long bond/short future. We have:

- a cash outflow from purchasing the bond;
- a cash inflow on delivery into the future, including the accrued interest to the delivery date;
- the cash borrowed to finance the trade.

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<sup>12</sup> Note that in some cases and vendor systems, the net basis appears to be positive because the negative sign is left off, under the assumption that users are aware that the net basis represents the loss from a long cash/short futures trade.

<sup>13</sup> As we shall see in Section 7.4.5, no assumptions need to be made when determining the implied repo rate, which is calculated from actual market-observed prices.

We simply therefore wish to have the percentage return of the investment over the borrowing cost. That is,

$$IRR = \frac{[(P_{futs} \times CF) + AI_{del}] - (P_{bond} + AI)}{P_{bond} + AI} \times \frac{M}{Days} \quad (7.6)$$

where  $M$  is the day-base, either 360 or 365 and  $Days$  is the term of the trade. There is no need to remember this version though, Burghardt<sup>14</sup> writes it simpler as:

$$IRR = \left( \frac{P_{invoice} - P_{bond}}{P_{bond}} \right) \times \left( \frac{360}{n} \right) \quad (7.7)$$

which is exactly identical to (7.6), with  $n$  for the number of days to delivery, and all prices still include accrued interest, at the time of the trade (bond) or to delivery (future). The formula written as (7.7) is easy to explain. The invoice price is the futures invoice price, the amount from the delivery on expiry. Of course the actual invoice price is a function of the final futures settlement price, but we adjust the current futures price with the conversion factor to allow for this.

Note that Bloomberg quotes the formula in still more simplified fashion, as:

$$IRR = \left( \frac{P_{futsinvoice}}{P_{bond}} - 1 \right) \times \left( \frac{360}{n} \right) \quad (7.8)$$

with the 360-day base associated with the US Treasury market.

Both (7.6) and (7.7) assume that no coupon is paid during the trade. If a coupon is paid during the trade, it is regarded as being reinvested, and the cash flow total must therefore include both the coupon and the reinvestment income generated. The reinvestment rate used in the market is one of the following:

- the implied repo rate;
- the bond's yield-to-maturity. This is described as being consistent with the bond yield calculation itself, which assumes reinvestment of coupon at the bond yield;
- the overnight repo rate, and rolled over. This is justified on the basis that traders in fact do not reinvest the coupon but use the funds to reduce funding costs.

The first two are assumed to apply to maturity, while the second must be calculated at the prevailing rate each day. If the reinvestment rate is assumed to be the IRR, it is the rate that results in:

$$P_{bond} \times \left[ 1 + IRR \left( \frac{n}{M} \right) \right] = P_{invoice} + \left( \frac{C}{2} \right) \times \left[ 1 + IRR \left( \frac{n_2}{M} \right) \right] \quad (7.9)$$

where  $n_2$  is the number of days between the coupon payment and the futures expiry (delivery) date. Expression (7.9) is then rearranged for the implied repo rate, to give us:

$$IRR = \frac{(P_{invoice} + \frac{C}{2} - P_{bond}) \times M}{(P_{bond} \times n) - (\frac{C}{2} \times n_2)} \quad (7.10)$$

The deliverable bond that has the highest implied repo rate is the *cheapest-to-deliver* bond or CTD. We see from the formula that the IRR is a function of the bond price, the value

<sup>14</sup> *Ibid*, page 14.

of which is compared to the forward price for the bond implied by futures price. As such the status of the CTD bond reflects the bond's price (in other words its yield). If the yield of a bond within the delivery basket moves sufficiently vis-à-vis the other deliverable bonds, it may become the CTD bond. A change in the cheapest bond is an important development and any such change should be anticipated in advance by good traders.

The bond with the highest implied repo rate will, almost invariably, have the lowest net basis. On rare occasions this will not be observed. When two bonds each have implied repo rates that are very similar, it is sometimes the case that the bond with the (slightly) lower implied repo rate has a (slightly) lower net basis.

The CTD bond is just that: the cheapest bond to deliver into the futures contract in terms of running costs. The short future has the delivery option, and will elect to deliver the CTD bond unless there is a reason it cannot, in which case it will deliver the next cheapest at greater cost to itself. Assuming that a basis trade is put on with the CTD bond against the future, if the CTD changes then the position becomes useless and will be unwound at great loss. The CTD bond is what the market will treat as the actual underlying bond of the futures contract, and it is closely observed. Pricing theory informs us that the futures price will track the CTD bond price; in fact it is the other way around, with the liquidity and transparency of the futures contract and its price meaning that the CTD bond price tracks that of the future. Under the terms of the long gilt contract, the CTD gilt can be delivered on any business day of the delivery month, but in practice only one of two days are ever used to make delivery, the first (business) day of the delivery month or the last (delivery) day of the month. If the current yield on the CTD gilt exceeds the money market repo rate, the bond will be delivered on the last business day of the month, because the short future earns more by holding on to the bond than by delivering it and investing the proceeds in the money market; otherwise the bond will be delivered on the first business day of the delivery month. Until very recently a gilt that was eligible for trading *special ex-dividend* on any day of the delivery month was not eligible for delivery into that gilt contract. However, from August 1998 the provision for special ex-dividend trading was removed from gilts, so this consideration no longer applies. Other gilts that are not eligible for delivery are index-linked, partly paid or convertible gilts.<sup>15</sup> For gilts the IRR for all deliverable bonds can be calculated using (7.6) in the normal way. However, if a bond goes ex-dividend between trade date and delivery date, a modification is required in which the interest accrued is negative during the ex-dividend period.

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<sup>15</sup> Gilts go ex-dividend seven business days before the coupon date, this being the record date to determine the investors that will receive the coupon. Prior to its withdrawal, counterparties could agree between themselves to trade ex-dividend up to two weeks before the ex-dividend date, this being known as *special ex-dividend*. During trading for the September 1997 long gilt contract, some market participants forgot (or were unaware) that gilts that were special ex-dividend at any time during the delivery month became ineligible for delivery, and had traded in the current CTD bond, the 9% 2008, under the assumption that they could deliver, or would be delivered into, of this bond. When the CTD bond changed it resulted in losses for parties that had not been aware of this. This despite the fact that LIFFE sent out a notice informing the market that the CTD for September 1997 would not be the 9% 2008 for this reason...

### Example 7.3: The implied repo rate

Another way of looking at the concept of the cheapest-to-deliver bond is in terms of the implied repo rate. The CTD bond is the bond that gives the highest implied repo rate (IRR) to the short from a cash-and-carry trade, that is a strategy of buying the bond (with borrowed funds) in the cash market and selling it forward into the futures market. The bond is funded in the repo market, and by selling it forward the trade is in effect a repo with the futures market, hence *implied* repo rate.

To illustrate, we calculate the IRR for the 9% Treasury 2008, a UK gilt, at the time that the “front month” contract was the December 1998 contract. The price of the gilt is 129.0834. The December 1998 long gilt futures contract is trading at 114.50. The date is 1 October. The money market rate on this date is 7.25%. As the current (or *running*) yield on the 9% 2008, at 6.972% is lower than the money market rate, it will be delivered at the beginning of December (that is, in 61 days from now). To identify the CTD bond, we would need to calculate the IRR for all eligible bonds. We use the conversion factor for the bond which is 1.140715, calculated and given out by LIFFE before the futures contract began trading.

The cash outflow in a cash-and-carry trade is:

Bond dirty price	129.0834
Interest cost (1 October – 1 December)	129.0834 × [0.0725 × (61/365)]
Total outflow	130.6474.

The bond (whose price includes 171 days’ accrued interest on 1 October) has to be financed at the money market rate of 7.25% for the 61 days between 1 October and 1 December, when the bond (if it is still the CTD) is delivered into the futures market.

The cash inflow per £100 nominal as a result of this trade is:

Implied clean price of bond on 1 December (futures price on 1 October multiplied by conversion factor)	114.50 × 1.1407155
Accrued interest (1 October – 1 December)	£9 × (61/365)
Total inflow	132.11603

The implied price of the bond on 1 December equals the futures price on 1 October multiplied by the conversion factor for the bond. Because the futures price is quoted clean, accrued interest has to be added to obtain the implied dirty price on 1 December.

This cash-and-carry trade which operates for 61 days from 1 October to 1 December generates a rate of return or *implied repo rate* of:

$$IRR = \left( \frac{132.11603 - 130.6474}{130.6474} \right) \times \frac{365}{61} \times 100$$

$$= 6.726\%.$$

### Example 7.4: Calculating gross basis, net basis and implied repo rate

The gross basis is the difference between the actual price of the bond and the forward price of the bond as implied by the price of the futures contract, and represents the carrying cost of the bond. This is the actual difference between the coupon gain and

reinvestment minus the carry costs (which is at the actual money market repo rate). A positive net basis represents the loss that would result from a long cash/short futures position, and therefore the theoretical gain from a short cash/long futures trade, where the actual repo rate is the reverse repo rate transacted when covering the short cash position. The implied repo rate is the theoretical return from a long cash/short futures trade, assuming that the trader is short the number of futures equal to the bond's conversion factor for each £100,000 nominal of bonds held. Any coupon payments are assumed to be reinvested at the implied repo rate.

The formula for net basis is given by:

$$(P_{bond} \times (1 + r \times Del/36500)) - ((P_{fut} \times CF) + AI_{del}) \quad (7.11)$$

where

$P_{bond}$	is the bond dirty price
$r$	is the actual repo rate (expressed as per cent $\times$ 100)
$Del$	is the days to delivery
$P_{fut}$	is the future's price
$CF$	is the bond's conversion factor
$AI_{del}$	is the bond's accrued interest to delivery.

For net basis calculations in Treasury or euro markets the appropriate 360-day basis is used.

The calculations are for the CTD bond for the long gilt contract, which was the 6¼% 2010 gilt. We use mid prices for the bond. The trade is buying the cash and simultaneously selling the future. Note that gilts accrue on actual/actual basis and there were 184 days in the interest period 25 May–25 November 2001. The accrued interest calculation is therefore  $[80/184 \times (6.25 \times 0.5)]$  for the first date and  $[126/184 \times (6.25 \times 0.5)]$  for the delivery date.

Settlement date	13 August 2001
Futures price	115.94
6¼% Treasury 25/11/10	110.20
Repo rate	4.90%
Conversion factor	0.9494956

#### Calculations

Cash out on 13/8/2001	110.20 plus accrued (80 days)	= 111.558696
Cash in on 28/9/2001	(115.94 $\times$ 0.9494956) plus accrued	= 110.08452 + 2.139946
	(46 days later)	= 112.2244659

#### Gross basis

$$110.20 - 110.0845199 = \mathbf{0.1154801}$$

#### Net basis

$$[111.558696 \times (1 + 4.90 \times 46/36500)] - 112.2244659 = \mathbf{0.0231432}$$

#### Implied repo rate

$$(112.2244659/111.558696 - 1) \times (365/46) \times 100 = \mathbf{4.735390\%}$$

These calculations are confirmed by looking at the Bloomberg screens YA and DLV for value on 13 August 2001. These are reproduced in Chapter 17 of the author's book *The Repo Handbook* (2002), published by Butterworth-Heinemann.

Page DLV on Bloomberg lists deliverable bonds for any selected futures contract. Bonds are listed in order of declining *implied repo rate*; the user can select in increasing or decreasing order of implied repo rate, basis, yield, maturity, coupon or duration. The user can also select the price source for the bonds (in our example set at "Bloomberg Generic" rather than any specific bank or market maker) and the current cash repo rate.

## 7.5 Selecting the cheapest-to-deliver bond

As we've discussed just now there are two competing definitions for identifying the bond that is the cheapest-to-deliver issue, and they almost always, but not always, identify the same issue as "cheapest". The general rule is that the issue with the highest implied repo rate, and/or the issue with the lowest net basis is the CTD bond. Most academic literature uses the first definition, whereas market practitioners often argue that the net basis method should be used since it measures the actual profit & loss for an actual cash-and-carry trade.

It is up to the individual trader to decide which method to use as the basis for analysis. For example Bloomberg<sup>®</sup> terminals use the IRR method. The justification for this is that many market participants accept that the IRR method is appropriate to the cash-and-carry investor seeking maximum return per dollar invested. The main area of disagreement regards those cases where an arbitrageur finances (repos) the cash side of the trade and the net basis measures their resulting profit or loss. In a Bloomberg analysis this net basis is presented as percentage points of par (the same units as price), although some practitioners express it as p&l per million bonds. It is primarily because the net basis is per par amount rather than per pound invested that the two methods occasionally identify different "cheapest" issues. Note that in practice net basis will always be a loss, otherwise traders would arbitrage an infinite amount of any issue with a profitable net basis. Therefore the basis method identifies the issue which has the *smallest loss* per million pounds nominal as the cheapest issue.

The only reason a trader is willing to accept this guaranteed loss is that they do not intend to follow through exactly with this trade to maturity. Being long of the basis, that is short futures, essentially gives the trader numerous delivery and trading options; the cost of these is the net basis that the trader pays. In effect the trader is buying options for the cost of the net basis. The number of options they buy is indicated by the *conversion factor*, since that is the hedge factor for the cheapest issue. Therefore the cost per option is the net basis divided by the conversion factor. When ranked by net basis per contract (that is, divided by the conversion factor), the cheapest by this method invariably agrees with the IRR method.

## 7.6 Trading the basis

### 7.6.1 *The basis position*

Basis trading or cash-and-carry trading is an arbitrage-driven activity that involves the simultaneous trading of cash bonds and exchange-traded bond futures contracts. Traders

speak of going “long the basis” or of “buying the basis” when they buy the bond and sell the future. The equivalent number of futures contracts to trade per 100,000 nominal value of cash bond is given by the conversion factor. The opposite position, buying the future and selling the cash bond, is known as “selling the basis” or “going short the basis”. Someone who is long the basis has bought the basis itself (hence the expression!) and will therefore profit if the basis increases, that is, the price of the bond increases relative to the price of the futures contract.<sup>16</sup> A trader who has sold the basis will gain if the basis decreases, that is the price of the bond falls relative to the futures contract price.

Ideally each side of the position will be executed simultaneously, and most derivatives exchanges have a basis trading facility that enables a party to undertake this. Certain government bond primary dealers will quote a price in the basis as well. If this is not possible, the trade can be put on separately, known as “legging into the trade” as each leg is carried out at different times. To do this, generally the cash bond position is put on first and then the futures position, as the latter is more liquid and transparent. Whichever way round the trade is effected though, this method carries with it some risk, as the price of the leg yet to be traded can move against you, complicating the completion of the trade.<sup>17</sup> If this happens there is a danger that the second leg is put on one or two ticks offside, and straight away the trade starts off at a loss. This should be avoided if at all possible. There is also a bid-offer spread to take into account, for both cash and future positions.

The arbitrageur hopes to generate profit from a basis trade, and this will be achieved from changes in the basis itself and/or gains from the funding or carry. If the net funding cost is positive, then this will add to any profit or reduce losses arising from changes in the basis. This is where the repo rate comes in. The trader may elect to fund the bond position, whether long or short, in overnight repo but generally the best approach is to fix a term repo, with expiry date matching the date at which the trader hopes to unwind the trade. This may be to the contract expiry date or before. If short the basis, it is vital that the repo desk is aware if there is any chance that the bond goes special, as this could prove costly unless the repo is fixed to the trade maturity. There is also a bid-offer spread to consider with the repo rate, and while this is usually quite small for GC repo, say as little as 3 basis points, it may be wider for specifics, from 10 to 20 basis points.

In the next chapter we consider further issues in trading the basis.

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<sup>16</sup> Remember, when we say the price of the future, we mean the price as adjusted by the relevant conversion factor.

<sup>17</sup> From personal experience the author will testify that this is an extremely stressful position to be in! Don't leg into the trade unless there is no alternative.



# Appendices

## Appendix 7.1: The conversion factor for the LIFFE long gilt future

Here we describe the process used for the calculation of the *conversion factor* or *price factor* for deliverable bonds of the long gilt contract. The contract specifies a bond of maturity  $8\frac{3}{4}$  –13 years and a notional coupon of 7%. For each bond that is eligible to be in the delivery basket, the conversion factor is given by the following expression:  $P(7)/100$  where the numerator  $P(7)$  is equal to the price per £100 nominal of the deliverable gilt at which it has a gross redemption yield of 7%, calculated as at the first day of the delivery month, less the accrued interest on the bond on that day. This calculation uses the formula given at (7.12) and the expression used to calculate accrued interest. The analysis is adapted, with permission, from LIFFE's technical document.

The numerator  $P(7)$  is given by (7.12):

$$P(7) = \frac{1}{1.035^{t/s}} \left( c_1 + \frac{c_2}{1.035} + \frac{C}{0.07} \left( \frac{1}{1.035} - \frac{1}{1.035^n} \right) + \frac{100}{1.035^n} \right) - AI \quad (7.12)$$

where

- $c_1$  is the cash flow due on the following quasi-coupon date, per £100 nominal of the gilt.  $c_1$  will be zero if the first day of the delivery month occurs in the ex-dividend period or if the gilt has a long first coupon period and the first day of the delivery month occurs in the first full coupon period.  $c_1$  will be less than  $C/2$  if the first day of the delivery month falls in a short first coupon period.  $c_1$  will be greater than  $C/2$  if the first day of the delivery month falls in a long first coupon period and the first day of the delivery month occurs in the second full coupon period
- $c_2$  is the cash flow due on the next but one quasi-coupon date, per £100 nominal of the gilt.  $c_2$  will be greater than  $C/2$  if the first day of the delivery month falls in a long first coupon period and in the first full coupon period. In all other cases,  $c_2 = C/2$
- $C$  is the annual coupon of the gilt, per £100 nominal
- $t$  is the number of calendar days from and including the first day of the delivery month up to but excluding the next quasi-coupon date
- $s$  is the number of calendar days in the full coupon period in which the first day of the delivery month occurs
- $n$  is the number of full coupon periods between the following quasi-coupon date and the redemption date
- $AI$  is the accrued interest per £100 nominal of the gilt.

The accrued interest used in the formula above is given according to the following procedures.

If the first day of the delivery month occurs in a standard coupon period, and the first day of the delivery month occurs on or before the ex-dividend date, then:

$$AI = \frac{t}{s} \times \frac{C}{2} \quad (7.13)$$

If the first day of the delivery month occurs in a standard coupon period, and the first day of the delivery month occurs after the ex-dividend date, then:

$$AI = \left(\frac{t}{s} - 1\right) \times \frac{C}{2} \quad (7.14)$$

where

- $t$  is the number of calendar days from and including the last coupon date up to but excluding the first day of the delivery month
- $s$  is the number of calendar days in the full coupon period in which the first day of the delivery month occurs.

If the first day of the delivery month occurs in a short first coupon period, and the first day of the delivery month occurs on or before the ex-dividend date, then:

$$AI = \frac{t^*}{s} \times \frac{C}{2} \quad (7.15)$$

If the first day of the delivery month occurs in a short first coupon period, and the first day of the delivery month occurs after the ex-dividend date, then:

$$AI = \left(\frac{t^* - n}{s}\right) \times \frac{C}{2} \quad (7.16)$$

where

- $t^*$  is the number of calendar days from and including the issue date up to but excluding the first day of the delivery month
- $n$  is the number of calendar days from and including the issue date up to but excluding the next quasi-coupon date.

If the first day of the delivery month occurs in a long first coupon period, and during the first full coupon period, then:

$$AI = \frac{u}{s_1} \times \frac{C}{2} \quad (7.17)$$

If the first day of the delivery month occurs in a long first coupon period, and during the second full coupon period and on or before the ex-dividend date, then:

$$AI = \left(\frac{p_1}{s_1} + \frac{p_2}{s_2}\right) \times \frac{C}{2} \quad (7.18)$$

If the first day of the delivery month occurs in a long first coupon period, and during the second full coupon period and after the ex-dividend date, then:

$$AI = \left(\frac{p_2}{s_2} - 1\right) \times \frac{C}{2} \quad (7.19)$$

where

- $u$  is the number of calendar days from and including the issue date up to but excluding the first day of the delivery month
- $s_1$  is the number of calendar days in the full coupon period in which the issue date occurs
- $s_2$  is the number of days in the next full coupon period after the full coupon period in which the issue date occurs
- $p_1$  is the number of calendar days from and including the issue date up to but excluding the next quasi-coupon date
- $p_2$  is the number of calendar days from and including the quasi-coupon date after the issue date up to but excluding the first day of the delivery month which falls in the next full coupon period after the full coupon period in which the issue date occurs.

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“Raisul, what shall we do? We have lost everything...”  
“Sharif, was there never anything in your life for which it was worth losing everything for?”

– *The Wind and The Lion* (MGM Films) 1974

# 8 The Gilt Bond Basis II

In this chapter we look in more detail at some fundamentals behind the gilt bond basis, including the factors that drive its behaviour, and we also consider the implications of the short future’s delivery option.

## 8.1 Analysing the basis

Having discussed, in the previous chapter, the theoretical foundation behind futures prices, it is nevertheless the case that they move out of sync with the no-arbitrage price and present arbitrage trading opportunities. A review of the Treasury or the gilt bond basis relative to the bond carry, would show that the basis has been greater than the carry frequently, and this would indicate mispricing in the futures contracts.<sup>1</sup> The anomalies in pricing are due to a number of factors, the principal one of which is that the short future has the option of delivery. That is, the short future picks which bond to deliver from the basket, and the time at which it is delivered. The long future simply accepts the bond that is delivered. It is this inequality that is the option element of the contract.

We will take a look at this, but first let us consider the principle behind no-arbitrage delivery.

### 8.1.1 *No-arbitrage futures price*<sup>2</sup>

At the expiration of a futures contract, after the exchange delivery settlement price is being determined, there should be no opportunity for a market participant to generate an arbitrage profit by buying bonds and selling futures; by definition, because on the last day of trading there is no uncertainty with regard to the carry costs of the bond to delivery. In fact certain exchanges arrange it so that the time between the last trading day and the date for delivery is identical to the settlement process in the cash market.<sup>3</sup> On the last day, someone buying cash bonds will receive value on the same day, and with the same accrued interest, as a long future being delivered into. Thus carry cost is no longer an uncertainty and the price of the futures contract in theory must equate to that of the cash bond. In other words, the basis is zero at this point.

---

<sup>1</sup> Burghardt (*ibid*), page 27.

<sup>2</sup> We follow the approach used in Plona (*ibid*, chapter 3).

<sup>3</sup> For instance the Bund contract on Eurex.

```

<HELP> for explanation.
Hit (NUMBER) <GO> to view Historical Basis/Repo
Cheapest to Deliver
LONG GILT FUTURE Dec01 G Z1 114.1
Set 9/17/01 Cheapest IRP= 5.97
Div 12/31/01
AS OF 12/27/01
PRICE AS DECIMALS? Y
Order DR re-sort? Y
Price Source Yield C.Factor Basis
DECIMAL Gross Implied Actual Net
105 Days Act/365 Repo% Repo% Basis
MASTER:
1) UKT 9 07/12/11 130.1640BGN 4.988 1.1381240 .304 5.97 4.17 -.681
2) UKT 6 1/4 11/25/10 108.4740BGN 5.056 .9505874 .012 5.66 4.17 -.469
3) UKT 8 09/27/13 126.3955BGN 5.000 1.0793560 3.241 -2.54 4.17 2.444
4) UKT 5 03/07/12 100.1195BGN 4.984 .8551727 2.544 -3.79 4.17 2.298
    
```

Australia 61 2 9777 8600 Brazil 5511 3048 4500 Europe 44 20 7330 7500 Germany 49 69 920410  
 Hong Kong 852 2977 6000 Japan 81 3 3201 8900 Singapore 65 212 1000 U.S. 1 212 318 2000 Copyright 2002 Bloomberg L.P.  
 6412-52-0 27-Aug-02 14:18:15



(a)

Figure 8.1 (a): Dec 01 long gilt delivery basket as at 17 September 2001. © Bloomberg L.P. Reproduced with permission.

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<HELP> for explanation.
Hit (NUMBER) <GO> to view Historical Basis/Repo
Cheapest to Deliver
LONG GILT FUTURE Dec01 G Z1 114.1
Set 9/17/01 Cheapest IRP= 56.01
Div 12/31/01
AS OF 12/27/01
PRICE AS DECIMALS? Y
Order DR re-sort? Y
Price Change Yield C.Factor Basis
DECIMAL Gross Implied Actual Net
105 Days Act/365 Repo% Repo% Basis
MASTER:
1) UKT 8 09/27/13 108.0373+2.00 7.000 1.0793560 -15.1 56.01 4.17 -16.1
2) UKT 5 03/07/12 85.3262+2.02 7.000 .8551727 -12.2 55.72 4.17 -12.7
3) UKT 6 1/4 11/25/10 94.9673+1.94 7.000 .9505874 -13.5 55.45 4.17 -14.1
4) UKT 9 07/12/11 114.0135+2.01 7.000 1.1381240 -15.8 55.35 4.17 -17.0
    
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Australia 61 2 9777 8600 Brazil 5511 3048 4500 Europe 44 20 7330 7500 Germany 49 69 920410  
 Hong Kong 852 2977 6000 Japan 81 3 3201 8900 Singapore 65 212 1000 U.S. 1 212 318 2000 Copyright 2002 Bloomberg L.P.  
 6412-52-0 27-Aug-02 14:18:45



(b)

Figure 8.1 (b): Dec 01 long gilt delivery basket with yields set at 7%. © Bloomberg L.P. Reproduced with permission.

Bond	Conversion factor	Price at 7% yield	Price divided by factor
6.25% Treasury 2010	0.9505874	94.9685	99.90506922
9% Conversion 2011	1.1381240	114.0107	100.1742341
8% Treasury 2013	1.0793560	108.0365	100.0894817
5% Treasury 2012	0.8551727	85.3286	99.7793779

**Table 8.1:** December 2001 long gilt delivery basket, price at 7% notional yield level, and zero-basis futures prices.

Consider Figure 8.1 (b), the delivery basket for the December 2001 long gilt contract. The bonds have been priced so that they yield 7%, the notional coupon. Under these conditions, only one futures price will satisfy the no-arbitrage principle. As carry is not an issue on expiry, the no-arbitrage condition is met provided there is a zero basis for one of the deliverable bonds and no negative basis for any of the other bonds. For instance, at a futures price of 100.09, following the price factor conversion the equivalent bond price would be below the market price of the 8% Treasury 2013 (the cheapest-to-deliver bond at this level) and thus maintain a positive basis. However, for the 6.25% Treasury 2010 bond, this futures price would be equivalent to a converted bond price of 95.1443. The market price of this bond is lower than this, at 94.9685. In theory a trader can buy the bond at this price, sell the futures contract at 100.09 and realise a trading gain of 0.1758 (the difference between the two prices). This is the arbitrage profit. So the initial suggested price for the futures contract is too high. At a price of 100.06 the future no longer presents an opportunity for profit if buying the basis, however, in theory, selling the basis against the 9% 2011 bond still generates profit. The long future must accept delivery of any of the bonds in the basket, however, and will not be delivered this bond. So the adjusted futures price is too low.

Hence we know that the arbitrage-free futures price lies between these two levels. In fact we obtain the no-arbitrage price by dividing the bonds' market prices by their respective conversion factor. These are shown in Table 8.1. The prices in Table 8.1 are the futures prices at which there exists a zero basis for that particular underlying bond. We can determine this relationship easily from the definition of the basis, as shown below:

$$Basis = P_{bond} / (P_{fut} \times CF) \quad (8.1)$$

therefore

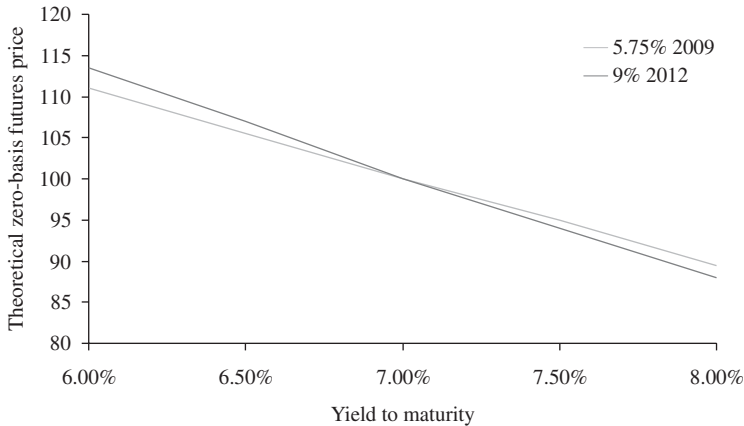
$$P_{bond} = Basis + (P_{fut} \times CF) \quad (8.2)$$

If we set the basis at zero, we obtain

$$P_{fut} = \frac{P_{bond}}{CF} \quad (8.3)$$

which illustrates how the deliverable bond price divided by its conversion factor is equal to the zero-basis futures price.

Taking this further, the futures price that would ensure that all the deliverable bonds have a basis that is either zero, or greater than zero, is the lowest possible zero-basis futures price. The price cannot exceed this otherwise there would be an arbitrage opportunity. If we calculate the zero-basis futures price at different yield levels, we will observe that when



**Figure 8.2:** Illustrating bias in the conversion factor, June 2000 long gilt.

yields lie above the contract notional coupon, generally the shortest-dated bond carries the lowest zero-coupon futures price. If yields lie below the notional coupon, frequently the longest-dated bond carries the lowest zero-basis futures price, and so is the CTD bond. This has been observed empirically by a number of authors, and formalised by Benninga (2001), for instance. The observation reflects a bias in the conversion factor. We illustrate this bias in Figure 8.2, for the shortest-dated and longest-dated deliverable bonds for the June 2000 long gilt future. It shows where the futures price meets for both bonds is at the contract notional coupon of 7%, this being known as the *inflection point*. The conversion factor bias determines which bond is the cheapest-to-deliver bond, based on yield levels of bonds in the basket and their position relative to the contract notional coupon.

The relative bias of the conversion factor is a function of the duration property of the bonds. For further information on this see Meisner and Labuszewski (1984) and Arak *et al.* (1986).

### 8.1.2 Options embedded in bond futures contracts

In the US Treasury bond contract, the short future has the following options with regard to delivery:

- the *wild card* or *time to deliver* option;
- the *quality option*.

The short future may deliver during any business day of the delivery month, although the administrative process involved takes place over three days. The first day is the *position day*, the first day on which the short declares an intent to deliver. The first possible day that this can occur is the second-to-last business day before the first day of the delivery month. There is an important advantage to the short future on this day: at 14.00 hours that day the exchange settlement price and hence the invoice amount to be received by the short are fixed. However, the short does not have to announce an intent

to deliver until 20.00 hours on that day. During the six hours after the settlement price, if interest rates rise and the bond price falls, the short will earn the difference between the actual price received for the bond, which is the EDSP set at 14.00, and the price that they will have to pay to acquire the bond. Equally if the bond is in the short's possession, the price received for the short future delivery will be higher than the market price of the bond. The second day is the *notice of intention day*, and during this day the exchange clearing house identifies the short and long parties to each other. The third day is the *delivery day*; during this day the short future must deliver the bond to the clearing house. The long future pays the invoice amount based on the settlement price fixed on the position day.

The short future has an option of when to exercise the *time to deliver* option from the penultimate business day prior to the start of the delivery month up to the last business day of the delivery month, known as the *last trading day*. At 14.00 hours on that day the final settlement price is determined, which stays constant to the end of the month. The short future is left with one more wild card at this point, known as the *end-of-the-month* option. Assuming that the short has not declared an intent to deliver until now, the settlement price for the contract is now irrevocably fixed. At this point the short still has five more days before having to declare an intention. In this case the possibility still exists for profit generation if, for example, the trader purchases the bond at the settlement price and holds it to delivery, earning the accrued interest. This will generate a carry profit if the bond's running yield is higher than its specific repo offer rate.

The last option advantage of the short future is the quality option. This is the option to deliver any of the bonds within the delivery basket. As we have seen, the bonds can vary widely in coupon and maturity, and hence yield, and despite the conversion factor equalisation there is a bias in this factor that means at yield levels above the notional coupon, long-dated bonds are the cheapest, and vice-versa if yields are below the notional level. The quality option also presents the long future with potential problems if there is a change in yields sufficient to change the CTD from one bond to another. If this comes as a surprise to the basis trader, it can be potentially very serious.

The delivery options available to the short future carry value, and this is reflected in the difference between the gross basis and the net basis. In theory the value of the delivery options, when added to the price of the futures contract, should equal the value of the bond together with the carry.

## 8.2 Bond delivery factors

### 8.2.1 *The cheapest-to-deliver*

The deliverable bond is of course the cheapest-to-deliver bond. This is not, as a junior trader once suggested to the author, the bond with the lowest market price (although it might well be). The CTD bond is the one that maximises the return to the arbitrageur engaging in buying the basis, that is buying the bond and simultaneously selling the future, holding the bond to expiry and then delivering it into the futures contract. Some market practitioners use the implied repo rate to identify the CTD, while others prefer the net basis method. We assess both now.

Essentially a good approximation for the CTD is to compare the basis for a bond with its total carry costs to delivery. The difference between the two is the net basis. However, this method may produce incorrect CTD rankings when the net basis values for two bonds are



very close. When this happens the net basis for the bond that is actually the cheapest is higher than another bond in the basket, despite the fact that it is the cheapest. This happens because since the net basis method measures cheapness by comparing net basis to the dirty price of the bond, and this price is related to coupon size, maturity and given yield levels, the actual running cost is sometimes not captured. This can produce a lower net basis for a bond that is not actually the cheapest. For this reason the most accurate method by which to identify the CTD is to pick the bond with the highest implied repo rate. From the previous chapter we saw that the IRR is the hypothetical return achieved by going long the basis and running this position to expiry. It is in effect a repo agreement with the futures market, and the calculation fully accounts for the bond's purchase price. The IRR method is recommended by academic writers because of the way that it is calculated:

$$IRR = \left( \frac{P_{invoice}}{P_{bond}} - 1 \right) \times \left( \frac{M}{n} \right) \quad (8.4)$$

where

$P_{invoice}$	is the invoice price
$P_{bond}$	is the cash bond purchase price
$M$	is the day base (365 or 360)
$n$	is the days to delivery.

From (8.4) we see that the bond currently trading at a price that results in the highest ratio of futures invoice price to purchase price will have the highest implied repo rate. In other words, the bond with the lowest purchase price *relative to its invoice price* is the CTD bond.

Nevertheless net basis is still popular amongst traders because it identifies the actual loss (when negative) from the basis trade, and as such is a more quantitative measure.

### 8.2.2 Selecting delivery time

Another advantage of the IRR measure is that it clearly indicates the time that the short future should deliver the bond. Consider Table 8.2 for the December 2000 long gilt contract.

This shows the implied repo rates for delivery on the first day of the delivery month and the last day of the month. For all of the bonds the IRR for delivery on the last day is higher

Bond	Closing day cash price	Conversion factor	Gross basis	Net basis	IRR to first delivery day %	IRR to last delivery day %	Actual repo rate %
5.75% 7 Dec 2009	106.0590	0.9174728	-0.166	-0.300	1.04	6.26	4.52
9% 12 Jul 2011	133.8585	1.1479281	0.951	0.509	-3.32	2.16	4.52
6.25% 25 Nov 2010	110.8310	0.9467478	1.217	1.040	-5.79	-1.28	4.52
9% 6 Aug 2012	136.2685	1.1576368	2.237	1.808	-6.78	-3.74	4.52
8% 27 Sep 2013	129.9925	1.0835676	4.537	4.190	-22.70	-15.74	4.52

**Table 8.2:** Identifying the cheapest-to-deliver and the optimum delivery time, December 2000 long gilt basket. (Source: LIFFE; JP Morgan).

than that for delivery on the first day. It is apparent that the (theoretical) return from a long basis trade would be higher if the delivery date was delayed to the last possible moment, and so in this case the short future would elect to deliver on the last business day.

In fact our illustration is a peculiar one, because the gilt yield curve was inverted at this time. In a positively sloped yield curve environment, higher IRRs will result for longer-term trades and the decision of the short over when to deliver is an obvious one. The other reason why the short future would prefer to delay delivery is because early delivery eliminates the value of the option element that the short future possesses. It is a bit like early exercise of an American option eliminating the option's time value. In a negative yield curve environment the decision is not so clear cut, although early delivery still removes the short's option advantage. However, the market repo rate would need to be considerably higher than the IRRs to justify early delivery, and this was not the case here. Where the market repo rate is higher, the short future will be running a carry cost each day the basis position is maintained, so this will suggest early delivery.

In theory there should only be two days when the short future delivers, the start or end of the delivery month, but changes in the yield curve, a particular bond yield level, and market repo rates may make it necessary to deliver on dates in between. Consider Table 8.3, which shows the delivery pattern for the September 1996 and December 1998 long gilt contract on LIFFE. In September 1996 the gilt yield curve was conventional and positively

September 1996			December 1998	
Date	9% 2011	7.75% 2006	Date	9% 2008
2			1	1,238
3			2	1,787
4			3	26
5			4	4,116
6			7	
9			8	200
10			9	
11			10	
12			11	8
13			14	
16			15	
17			16	
18			17	
19			18	3
20			21	
23			22	
24			23	
25	16		24	
26			29	
27	3,500	4,515	30	
Total	3,516	4,515		7,378

**Table 8.3:** Bond delivery patterns for two futures contracts, reflecting the shape of the yield curve at time of delivery. (Source: LIFFE).

sloping, and apart from a small handful of deliveries just prior, all deliveries were made on the last eligible day of the month. In December 1998 however the yield curve was negatively sloping, and this is reflected in the pattern of deliveries. It would appear that some market participants had confused ideas, and although in general bonds were delivered early in the month, some deliveries were still being made right in to the middle of the month. This despite the fact the delivery parties would be experiencing negative carry each day they did not deliver. Essentially, this would have been a cost to all those that did not deliver on the first day.

### 8.2.3 Changes in CTD status

A bond may be replaced as CTD if there are changes in relative yield levels of deliverable bonds, if the shape of the yield curve changes, or if specific repo rates turn special for certain bonds and not others. Benninga (2001) amongst others has identified the following general rules:

- where the yield level is below the notional coupon level, the bond with the lowest duration will be the CTD. If the yield level is higher than the notional, the bond with the highest duration will be the CTD;
- where bonds have roughly identical durations, the bond with the highest yield will be the CTD.

Bond yields are relative however, and the bonds in the basket will trade at different yield levels. A large *relative* shift can bring about a change in CTD status, while overall yields remain roughly at the same level. A more significant yield shift or change in the shape of the curve can also have this effect. The yield on any particular bond is market-determined, and is a function of a number of factors, such as its liquidity, benchmark status, and so on. If there are two or more bonds in the delivery basket with approximately identical duration values, the bond with the higher yield would have the lower converted price, and therefore would be the CTD bond.

Remember that duration<sup>4</sup> is an approximate measure of the percentage change in the price of a bond for a 1% change in the bond's yield. For a given change in yield then, the prices of bonds of higher duration will change by a greater amount than lower-duration bonds. This is worth bearing in mind because it is behind the bias in the conversion factor introduced in the previous section. Let us reiterate this here. A contract's conversion factors are the approximate prices at which deliverable bonds yield the notional yield level. For the Treasury long bond then, all conversion factors are approximately neutral at a yield level of 6%. If every bond in the delivery basket was trading at 6% yield, their converted prices (the price at this yield, divided by the relevant conversion factor) should be equal to 100, or close to 100. At this yield level then, the short future is in theory indifferent as to which bond to deliver. However, at yield levels above or below the notional level of 6%, duration of the deliverable bonds becomes relevant.

At yields below 6%, as yields fall the rise in price of a lower-duration bond is relatively lower than the price rise of a higher-duration bond. Thus, the lower-duration bond becomes the CTD bond. As yields rise above 6%, the higher-duration bond experiences a smaller fall in price than the lower-duration bond, and it becomes the CTD bond.

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<sup>4</sup> We refer here of course to modified duration, which is usually simply termed "duration" in the US Treasury market.

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The dreamers of the day are dangerous men, for they may act out their dream with open eyes, to make it possible. This I did.

– *Seven Pillars of Wisdom*, T.E. Lawrence (1888–1935)

# 9 Information Content of the Gilt Yield Curve

The analysis and pricing activity that takes place in the gilt market revolves around the gilt yield curve. The yield curve describes the relationship between a particular redemption yield and a bond's maturity. Plotting the yield of gilts along the maturity term structure will give us the gilt yield curve. The primary yield curve in any domestic capital market is the government bond yield curve, so for example in the US market it is the US Treasury yield curve and in the UK it is the gilt curve.

In this chapter we will consider the yield to maturity yield curve as well as other types of yield curve that may be constructed from gilt yields.

## 9.1 Using the yield curve

Let us first consider the main uses of the yield curve. All participants in the debt capital markets have an interest in the current shape and level of the yield curve, as well as what this information implies for the future. The main uses are summarised below.

### ***Setting the yield for all debt market instruments***

The yield curve essentially fixes the cost of money over the maturity term structure. The yields of government bonds from the shortest-maturity instrument to the longest set the benchmark for yields for all other debt instruments in the market, around which all debt instruments are analysed. Issuers of debt (and their underwriting banks) therefore use the yield curve to price bonds and all other debt instruments. Generally the zero-coupon yield curve is used to price new issue securities, rather than the redemption yield curve.

### ***Acting as an indicator of future yield levels***

As we discuss later in this chapter, the yield curve assumes certain shapes in response to market expectations of the future interest rates. Bond market participants analyse the present shape of the yield curve in an effort to determine the implications regarding the future direction of market interest rates. This is perhaps one of the most important functions of the yield curve, and it is as much an art as a science. The yield curve is scrutinised for its information content not just by bond traders and fund managers but also by corporate financiers as part of project appraisal. Central banks and government treasury departments also analyse the yield curve for its information content, not just regarding forward interest rates but also with regard to expected inflation levels.

### ***Measuring and comparing returns across the maturity spectrum***

Portfolio managers use the yield curve to assess the relative value of investments across the maturity spectrum. The yield curve indicates the returns that are available at different maturity points and is therefore very important to fixed-income fund managers, who can use it to assess which point of the curve offers the best return relative to other points.

### ***Indicating relative value between different bonds of similar maturity***

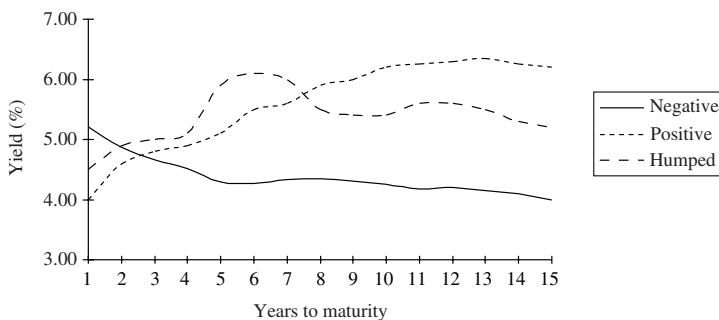
The yield curve can be analysed to indicate which bonds are cheap or dear to the curve. Placing bonds relative to the zero-coupon yield curve helps to highlight which bonds should be bought or sold either outright or as part of a bond spread trade.

### ***Pricing interest rate derivative securities***

The price of derivative securities revolves around the yield curve. At the short end, products such as Forward Rate Agreements are priced off the futures curve, but futures rates reflect the market's view on forward three-month cash deposit rates. At the longer end, interest rate swaps are priced off the yield curve, while hybrid instruments that incorporate an option feature such as convertibles and callable bonds also reflect current yield curve levels. The "risk-free" interest rate, which is one of the parameters used in option pricing, is the T-bill rate or short-term government repo rate, both constituents of the money market yield curve.

## **9.2 Yield to maturity yield curve**

The most commonly occurring yield curve is the yield to maturity yield curve. The curve itself is constructed by plotting the yield to maturity against the term to maturity for a group of bonds of the same class. Three different examples are shown at Figure 9.1. Bonds used in constructing the curve will only rarely have an exact number of whole years to redemption; however it is often common to see yields plotted against whole years on the  $x$ -axis. This is because once a bond is designated the *benchmark* for that term, its yield is taken to be the representative yield. For example, the then ten-year benchmark bond in the UK gilt market, the 5 $\frac{3}{4}$ % Treasury 2009, maintained its benchmark status throughout 1999 and into 2000, even as its term to maturity fell below ten years. The yield to maturity yield curve is the most commonly observed curve simply because yield to maturity is the most frequent measure of return used. The business sections of daily newspapers, where they quote bond yields at all, usually quote bond yields to maturity.



**Figure 9.1:** Yield to maturity yield curves.

As we might expect, given the source data from which it is constructed, the yield to maturity yield curve contains some inaccuracies. In particular the assumption of a constant rate for coupon reinvestment during the bond's life at the redemption yield level. Since market rates will fluctuate over time, it will not be possible to achieve this (a feature known as *reinvestment risk*). Only zero-coupon bondholders avoid reinvestment risk as no coupon is paid during the life of a zero-coupon bond.

The yield to maturity yield curve does not distinguish between different payment patterns that may result from bonds with different coupons, that is, the fact that low-coupon bonds pay a higher portion of their cash flows at a later date than high-coupon bonds of the same maturity. The curve also assumes an even cash flow pattern for all bonds. Therefore in this case cash flows are not discounted at the appropriate rate for the bonds in the group being used to construct the curve. To get around this, bond analysts may sometimes construct a *coupon yield curve*, which plots yield to maturity against term to maturity for a group of bonds with the same coupon. This may be useful when a group of bonds contains some with very high coupons; high coupon bonds often trade "cheap to the curve", that is they have higher yields than corresponding bonds of the same maturity but lower coupon. This is usually because of reinvestment risk and, in some markets (including the UK), for tax reasons.

For the reasons we have discussed the market often uses other types of yield curve for analysis when the yield to maturity yield curve is deemed unsuitable.

Figure 9.2 shows the Bloomberg page IYC with gilt benchmark and gilt strips curve selected as at 16 August 2002, while Figure 9.3 shows page IYCM and the benchmark curve for one year earlier, for comparison.

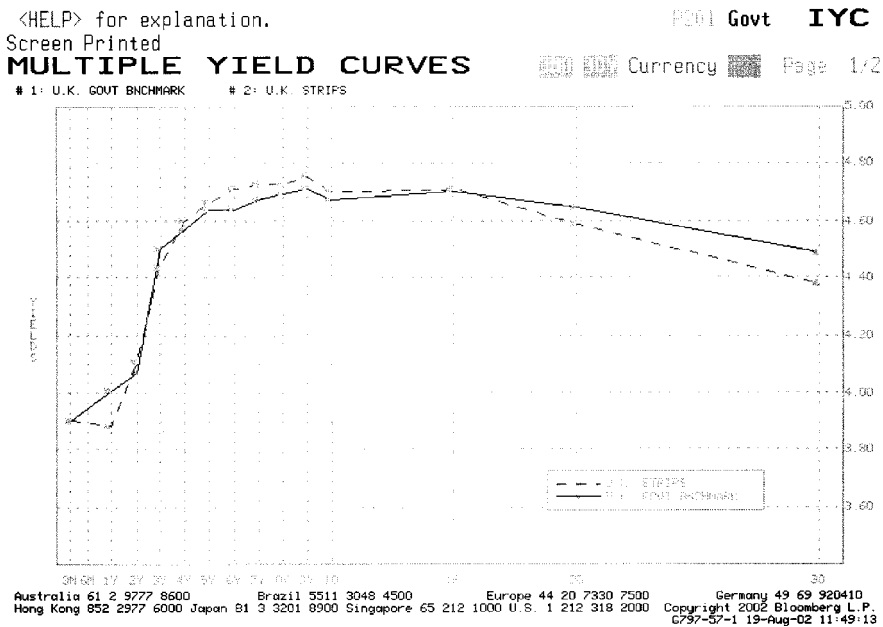
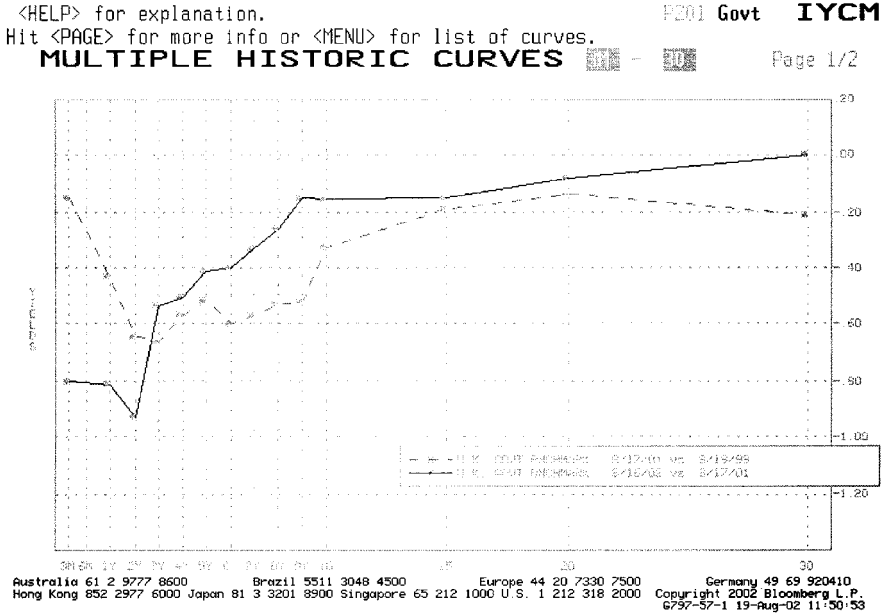


Figure 9.2: Bloomberg page IYC, benchmark gilt and strips curve, August 2002.





**Figure 9.3:** Bloomberg page IYCM, historic gilt benchmark yield curves, August 2001 and August 2002.

### 9.3 The zero-coupon (or spot) yield curve

The *zero-coupon (or spot) yield curve* plots zero-coupon yields (or spot yields) against term to maturity. A zero-coupon yield is the yield prevailing on a bond that has no coupons. In the first instance if there is a liquid zero-coupon bond market we can plot the yields from these bonds if we wish to construct this curve. However, it is not necessary to have a set of zero-coupon bonds in order to construct the curve, as we can derive it from a coupon or par yield curve; in fact in many markets where no zero-coupon bonds are traded, a spot yield curve is derived from the conventional yield to maturity yield curve. This is, of course, a *theoretical* zero-coupon (spot) yield curve, as opposed to the *market* or *observed* spot curve that can be constructed using the yields of actual zero-coupon bonds trading in the market.<sup>1</sup>

<sup>1</sup> It is common to see the terms “spot rate” and “zero-coupon rate” used synonymously. However, the spot rate is a theoretical construct and cannot be observed in the market. The definition of the spot rate, which is the rate of return on a single cash flow that has been dealt today and is received at some point in the future, comes very close to that of the yield on a zero-coupon bond, which can be observed directly in the market. Zero-coupon rates can therefore be taken to be spot rates in practice, which is why the terms are frequently used interchangeably.

### 9.3.1 Basic concepts

Spot yields must comply with equation (9.1). This equation assumes annual coupon payments and that the calculation is carried out on a coupon date so that accrued interest is zero.

$$\begin{aligned}
 P_d &= \sum_{n=1}^N \frac{C}{(1 + rs_n)^n} + \frac{M}{(1 + rs_N)^N} \\
 &= \sum_{n=1}^N C \cdot df_n + M \cdot df_N
 \end{aligned} \tag{9.1}$$

where

$rs_n$  is the spot or zero-coupon yield on a bond with  $n$  years to maturity  
 $df_n = 1/(1 + rs_n)^n$  is the corresponding *discount factor*.

In (9.1)  $rs_1$  is the current one-year spot yield,  $rs_2$  the current two-year spot yield, and so on. Theoretically the spot yield for a particular term to maturity is the same as the yield on a zero-coupon bond of the same maturity, which is why spot yields are also known as zero-coupon yields.

This last point is an important result, as spot yields can be derived from redemption yields that have been observed in the market.

As with the yield to redemption yield curve, the spot yield curve is commonly used in the market. It is viewed as the true term structure of interest rates because there is no reinvestment risk involved; the stated yield is equal to the actual annual return. That is, the yield on a zero-coupon bond of  $n$  years' maturity is regarded as the true  $n$ -year interest rate. Because the observed government bond redemption yield curve is not considered to be the true interest rate, analysts often construct a theoretical spot yield curve. Essentially this is done by breaking down each coupon bond being observed into its constituent cash flows, which become a series of individual zero-coupon bonds. For example, £100 nominal of a 5% two-year bond (paying annual coupons) is considered equivalent to £5 nominal of a one-year zero-coupon bond and £105 nominal of a two-year zero-coupon bond.

Let us assume that in the market there are 30 bonds all paying annual coupons. The first bond has a maturity of one year, the second bond of two years, and so on out to thirty years. We know the price of each of these bonds, and we wish to determine what the prices imply about the market's estimate of future interest rates. We naturally expect interest rates to vary over time, but that all payments being made on the same date are valued using the same rate. For the one-year bond we know its current price and the amount of the payment (comprised of one coupon payment and the redemption proceeds) we will receive at the end of the year; therefore we can calculate the interest rate for the first year: assume the one-year bond has a coupon of 5%. If the bond is priced at par and we invest £100 today we will receive £105 in one year's time, hence the rate of interest is apparent and is 5%. For the two-year bond we use this interest rate to calculate the future value of its current price in one year's time: *this is how much we would receive if we had invested the same amount in the one-year bond*. However, the two-year bond pays a coupon at the end of the first year; if we subtract this amount from the future value of the current price, the net amount is what we should be giving up in one year in return for the one remaining payment. From these numbers we can calculate the interest rate in year two.

Assume that the two-year bond pays a coupon of 6% and is priced at 99.00. If the £99.00 was invested at the rate we calculated for the one-year bond (5%), it would accumulate

£103.95 in one year, made up of the £99 investment and interest of £4.95. On the payment date in one year's time, the one-year bond matures and the two-year bond pays a coupon of 6%. If everyone expected that at this time the two-year bond would be priced at more than 97.95 (which is 103.95 minus 6.00), then no investor would buy the one-year bond, since it would be more advantageous to buy the two-year bond and sell it after one year for a greater return. Similarly if the price was less than 97.95 no investor would buy the two-year bond, as it would be cheaper to buy the shorter bond and then buy the longer-dated bond with the proceeds received when the one-year bond matures. Therefore the two-year bond must be priced at exactly 97.95 in 12 months' time. For this £97.95 to grow to £106.00 (the maturity proceeds from the two-year bond, comprising the redemption payment and coupon interest), the interest rate in year two must be 8.20%. We can check this using the present value formula covered earlier. At these two interest rates, the two bonds are said to be in equilibrium.

This is an important result and shows that (in theory) there can be no arbitrage opportunity along the yield curve; using interest rates available today the return from buying the two-year bond must equal the return from buying the one-year bond and rolling over the proceeds (or *reinvesting*) for another year. This is known as the *break-even principle*, a law of no-arbitrage.

Using the price and coupon of the three-year bond we can calculate the interest rate in year three in precisely the same way. Using each of the bonds in turn, we can link together the *implied one-year rates* for each year up to the maturity of the longest-dated bond. The process is known as *bootstrapping*. The "average" of the rates over a given period is the spot yield for that term: in the example given above, the rate in year one is 5%, and in year two is 8.20%. An investment of £100 at these rates would grow to £113.61. This gives a total percentage increase of 13.61% over two years, or 6.588% per annum (the average rate is not obtained by simply dividing 13.61 by 2, but – using our present value relationship again – by calculating the square root of "1 plus the interest rate" and then subtracting 1 from this number). Thus the one-year yield is 5% and the two-year yield is 8.20%.

In real-world markets it is not necessarily as straightforward as this; for instance on some dates there may be several bonds maturing, with different coupons, and on some dates there may be no bonds maturing. It is most unlikely that there will be a regular spacing of bond redemptions exactly one year apart. For this reason it is common for analysts to use a software model to calculate the set of implied spot rates which best fits the market prices of the bonds that do exist in the market. For instance if there are several one-year bonds, each of their prices may imply a slightly different rate of interest. We choose the rate which gives the smallest average price error. In practice all bonds are used to find the rate in year one, all bonds with a term longer than one year are used to calculate the rate in year two, and so on. The zero-coupon curve can also be calculated directly from the coupon yield curve using a method similar to that described above; in this case the bonds would be priced at par and their coupons set to the par yield values.

The zero-coupon yield curve is ideal to use when deriving implied forward rates, which we consider next, and defining the term structure of interest rates. It is also the best curve to use when determining the *relative value*, whether cheap or dear, of bonds trading in the market, and when pricing new issues, irrespective of their coupons. However, it is not an absolutely accurate indicator of average market yields because most bonds are not zero-coupon bonds.

### 9.3.2 Zero-coupon discount factors

Having introduced the concept of the zero-coupon curve in the previous paragraph, we can illustrate more formally the mathematics involved. When deriving spot yields from redemption yields, we view conventional bonds as being made up of an *annuity*, which is the stream of fixed coupon payments, and a zero-coupon bond, which is the redemption payment on maturity. To derive the rates we can use (9.1), setting  $P_d = M = 100$  and  $C = rm_N$ , as shown in (9.2) below. This has the coupon bonds trading at par, so that the coupon is equal to the yield.

$$\begin{aligned} 100 &= rm_N \cdot \sum_{n=1}^N df_n + 100 \cdot df_N \\ &= rm_N \cdot A_N + 100 \cdot df_N \end{aligned} \quad (9.2)$$

where  $rm_N$  is the par yield for a term to maturity of  $N$  years, where the discount factor  $df_N$  is the fair price of a zero-coupon bond with a par value of £1 and a term to maturity of  $N$  years, and where

$$A_N = \sum_{n=1}^N df_n = A_{N-1} + df_N \quad (9.3)$$

is the fair price of an annuity of £1 per year for  $N$  years (with  $A_0 = 0$  by convention). Substituting (9.3) into (9.2) and rearranging will give us the expression below for the  $N$ -year discount factor, shown at (9.4):

$$df_N = \frac{1 - rm_N \cdot A_{N-1}}{1 + rm_N} \quad (9.4)$$

If we assume one-year, two-year and three-year redemption yields for bonds priced at par to be 5%, 5.25% and 5.75% respectively, we will obtain the following solutions for the discount factors:

$$\begin{aligned} df_1 &= \frac{1}{1 + 0.005} = 0.95238 \\ df_2 &= \frac{1 - (0.0525)(0.95238)}{1 + 0.0525} = 0.90261 \\ df_3 &= \frac{1 - (0.0575)(0.95238 + 0.90261)}{1 + 0.0575} = 0.84476. \end{aligned}$$

We can confirm that these are the correct discount factors by substituting them back into equation (9.2); this gives us the following results for the one-year, two-year and three-year par value bonds (with coupons of 5%, 5.25% and 5.75% respectively):

$$\begin{aligned} 100 &= 105 \times 0.95238 \\ 100 &= 5.25 \times 0.95238 + 105.25 \times 0.90261 \\ 100 &= 5.75 \times 0.95238 + 5.75 \times 0.90261 + 105.75 \times 0.84476 \end{aligned}$$

Now that we have found the correct discount factors it is relatively straightforward to calculate the spot yields using equation (9.1), and this is shown below:

$$df_1 = \frac{1}{(1 + rs_1)} = 0.95238 \text{ which gives } rs_1 = 5.0\%$$

$$df_2 = \frac{1}{(1 + rs_2)^2} = 0.90261 \text{ which gives } rs_2 = 5.269\%$$

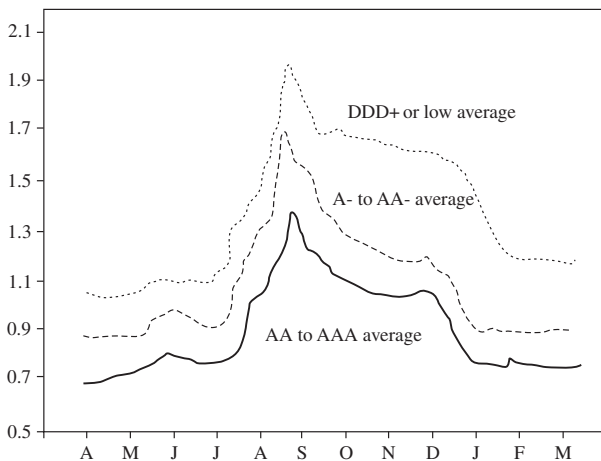
$$df_3 = \frac{1}{(1 + rs_3)^3} = 0.84476 \text{ which gives } rs_3 = 5.778\%$$

Equation (9.1) discounts the  $n$ -year cash flow (comprising the coupon payment and/or principal repayment) by the corresponding  $n$ -year spot yield. In other words  $rs_n$  is the *time-weighted rate of return* on an  $n$ -year bond. Thus as we said in the previous section the spot yield curve is the correct method for pricing or valuing any cash flow, including an irregular cash flow, because it uses the appropriate discount factors. That is, it matches each cash flow to the discount rate that applies to the time period in which the cash flow is paid. Compare this to the approach for the yield-to-maturity procedure discussed earlier, which discounts all cash flows by the same yield to maturity. This illustrates neatly why the  $N$ -period zero-coupon interest rate is the true interest rate for an  $N$ -year bond.

The expressions above are solved algebraically in the conventional manner, although those wishing to use a spreadsheet application such as Microsoft Excel<sup>®</sup> can input the constituents of each equation into individual cells and solve using the “Tools” and “Goal Seek” functions.

### 9.3.3 Yield curve spreads

The convention in the markets is to quote the yield on a non-government bond as a certain *spread* over the yield on the equivalent maturity government bond, usually using gross redemption yields. Traders and investment managers will assess the relative merits of holding the non-government bond based on the risk associated with the bond’s issuer and the magni-



**Figure 9.4:** Average yield spreads of UK corporate bonds versus gilts, 1998/1999. (Source: Halifax plc).

tude of its yield spread. For example, in the UK at the beginning of 1999 companies such as National Grid, Severn Trent Water, Abbey National plc and Tesco plc issued sterling denominated bonds, all of which paid a certain spread over the equivalent gilt bond.<sup>2</sup> Figure 9.4 shows the average yield spreads of corporate bonds over gilts in the UK market through 1998/99.

Traditionally investors will compare the redemption yield of the bond they are analysing with the redemption yield of the equivalent government bond. Just as with the redemption yield measure, however, there is a flaw with this measure, in that the spread quoted is not really comparing like-for-like, as the yields do not reflect the true term structure given by the spot rate curve. There is an additional flaw if the cash flow streams of the two bonds do not match, which in practice they will do only rarely.

Therefore the correct method for assessing the yield spread of a corporate bond is to replicate its cash flows with those of a government bond, which can be done in theory by matching the cash flows of the corporate bond with a package of government zero-coupon bonds of the same nominal value. If no zero-coupon bond market exists, the cash flows can be matched synthetically by valuing a coupon bond's cash flows on a zero-coupon basis. The corporate bond's price is, of course, the sum of the present value of all its cash flows, which should be valued at the spot rates in place for each cash flow's maturity. It is the yield spread of each individual cash flow over the equivalent maturity government spot rate that is then taken to be the true yield spread.

This measure is known in US markets as the *zero-volatility spread* or *static spread*, and it is a measure of the spread that would be realised over the government spot rate yield curve if the corporate bond were to be held to maturity. It is therefore a different measure to the traditional spread, as it is not taken over one point on the (redemption yield) curve but over the whole term to maturity. The zero-volatility spread is that spread which equates the present value of the corporate bond's cash flows to its price, where the discount rates are each relevant government spot rates. The spread is found through an iterative process, and it is a more realistic yield spread measure than the traditional one.

## 9.4 The forward yield curve

### 9.4.1 *Forward yields*

Most transactions in the market are for immediate delivery, which is known as the *cash* market, although some markets also use the expression *spot* market, which is more common in foreign exchange. Cash market transactions are settled straight away, with the purchaser of a bond being entitled to interest from the settlement date onwards.<sup>3</sup> There is a large market in *forward* transactions, which are trades carried out today for a forward settlement date. For financial transactions that are forward transactions, the parties to the trade agree today to exchange a security for cash at a future date, but at a price agreed today. So the *forward rate* applicable to a bond is the spot bond yield as at the forward date. That is, it is the yield of a zero-coupon bond that is purchased for settlement at the forward

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<sup>2</sup> The spread is, of course, not fixed and fluctuates with market conditions and supply and demand.

<sup>3</sup> We refer to "immediate" settlement, although of course there is a delay between trade date and settlement date, which can be anything from one day to seven days, or even longer in some markets. The most common settlement period is known as "spot" and is two business days.

date. It is derived today, using data from a present-day yield curve, so it is not correct to consider forward rates to be a prediction of the spot rates as at the forward date.

Forward rates can be derived from spot interest rates. Such rates are then known as *implied* forward rates, since they are implied by the current range of spot interest rates. The *forward* (or *forward-forward*) *yield curve* is a plot of forward rates against term to maturity. Forward rates satisfy expression (9.5):

$$\begin{aligned}
 P_d &= \frac{C}{(1 + {}_0rf_1)} + \frac{C}{(1 + {}_0rf_1)(1 + {}_1rf_2)} + \cdots + \frac{M}{(1 + {}_0rf_1) \cdots (1 + {}_{N-1}rf_N)} \\
 &= \sum_{n=1}^N \frac{C}{\prod_{i=1}^n (1 + {}_{i-1}rf_i)} + \frac{M}{\prod_{i=1}^N (1 + {}_{i-1}rf_i)} \quad (9.5)
 \end{aligned}$$

where  ${}_{N-1}rf_N$  is the implicit forward rate (or forward-forward rate) on a one-year bond maturing in year  $N$ .

As a forward or forward-forward yield is implied from spot rates, the forward rate is a forward zero-coupon rate. Comparing (9.1) and (9.5) we see that the spot yield is the *geometric mean* of the forward rates, as shown below:

$$(1 + rs_n)^n = (1 + {}_0rf_1)(1 + {}_1rf_2) \cdots (1 + {}_{n-1}rf_n). \quad (9.6)$$

This implies the following relationship between spot and forward rates:

$$\begin{aligned}
 (1 + {}_{n-1}rf_n) &= \frac{(1 + rs_n)^n}{(1 + rs_{n-1})^{n-1}} \\
 &= \frac{df_{n-1}}{df_n} \quad (9.7)
 \end{aligned}$$

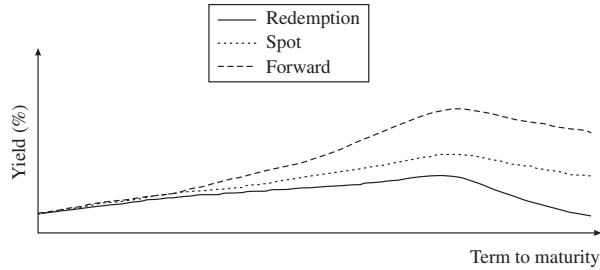
Using the spot yields we calculated in the earlier paragraph we can derive the implied forward rates from (9.7). For example, the two-year and three-year forward rates are given by:

$$\begin{aligned}
 (1 + {}_1rf_2) &= \frac{(1 + 0.05269)^2}{(1 + 0.05)} = 5.539\% \\
 (1 + {}_2rf_3) &= \frac{(1 + 0.05778)^3}{(1 + 0.05269)^2} = 6.803\%
 \end{aligned}$$

Using our expression gives us  ${}_0rf_1$  equal to 5%,  ${}_1rf_2$  equal to 5.539% and  ${}_2rf_3$  as 6.803%. This means, for example, that given current spot yields, which we calculated from the one-year, two-year and three-year bond redemption yields (which were priced at par), the market is expecting the yield on a bond with one year to maturity in three years' time to be 6.803% (that is, the three year one-period forward-forward rate is 6.803%).

The relationship between the par yields, spot yields and forward rates is shown in Table 9.1.

Figure 9.5 highlights our results for all three yield curves graphically. This illustrates another important property of the relationship between the three curves, in that as the original coupon yield curve was positively sloping, so the spot and forward yield curves lie above it. The reasons behind this will be considered later in the chapter.



**Figure 9.5:** Redemption, spot and forward yield curves: traditional analysis.

Let us now consider the following example. Suppose that a two-year bond with cash flows of £5.25 at the end of year 1 and £105.25 at the end of year 2 is trading at par, hence it has a redemption yield (indeed a par yield) of 5.25% (this is the bond in our table below). As we showed in the section on zero-coupon yields and the idea of the break-even principle, in order to be regarded as equivalent to this a pure zero-coupon bond or discount bond making a lump sum payment at the end of year 2 only (so with no cash flow at the end of year 1) would require a rate of return of 5.269%, which is the spot yield. That is, for the same investment of £100 the maturity value would have to be £110.82 (this figure is obtained by multiplying 100 by  $(1 + 0.05269)^2$ ).

This illustrates why the zero-coupon curve is important to corporate financiers involved in new bond issues. If we know the spot yields then we can calculate the coupon required on a new three-year bond that is going to be issued at par in this interest-rate environment by making the following calculation:

$$100 = \frac{C}{(1.05)} + \frac{C}{(1.05269)^2} + \frac{C + 100}{(1.05778)^3}$$

This is solved in the conventional algebraic manner to give  $C$  equal to 5.75%.

The relationship between spot yields and forward rates was shown at (9.7). We can illustrate it as follows. If the spot yield is the *average return*, then the forward rate can be interpreted as the *marginal return*. If the marginal return between years 2 and 3 increases from 5.539% to 6.803%, then the average return increases from 5.269% up to the three-year spot yield of 5.778% as shown below:

$$\left( (1.05269)^2 (1.06803) \right)^{1/3} - 1 = 0.05777868$$

or 5.778%, as shown in Table 9.1.

Year	Coupon yield (%)	Zero-coupon yield (%)	Forward rate (%)
1	5.000	5.000	5.000
2	5.250	5.269	5.539
3	5.750	5.778	6.803

**Table 9.1:** Coupon, spot and forward yields.



### Formula summary

The forward zero-coupon rate from interest period  $a$  to period  $b$  is given by (9.8):

$$\left( \frac{(1 + rs_b)^b}{(1 + rs_a)^a} \right)^{1/(b-a)} - 1 \quad (9.8)$$

where  $rs_a$  and  $rs_b$  are the  $a$  and  $b$  period spot rates respectively.

The forward rate from interest period  $a$  to period  $(a + 1)$  is given by (9.9):

$${}_a r f_{a+1} = \frac{(1 + rs_{a+1})^{a+1}}{(1 + rs_a)^a} - 1 \quad (9.9)$$

### 9.4.2 Calculating spot rates from forward rates

The previous section showed the relationship between spot and forward rates. Just as we have derived forward rates from spot rates based on this mathematical relationship, it is possible to reverse this and calculate spot rates from forward rates. If we are presented with a forward yield curve, plotted from a set of one-period forward rates, we can use this to construct a spot yield curve. Equation (9.6) states the relationship between spot and forward rates, rearranged as (9.10) to solve for the spot rate:

$$rs_n = ((1 + {}_1 r f_1) \times (1 + {}_2 r f_1) \times (1 + {}_3 r f_1) \times \cdots \times (1 + {}_n r f_1))^{1/n} - 1 \quad (9.10)$$

where  ${}_1 r f_1$ ,  ${}_2 r f_1$ ,  ${}_3 r f_1$  are the one-period versus two-period, two-period versus three-period forward rates up to the  $(n - 1)$  period versus  $n$ -period forward rates.

Remember to adjust (9.10) as necessary if dealing with forward rates relating to a deposit of a different interest period. If we are dealing with the current six-month spot rate and implied six-month forward rates, the relationship between these and the  $n$ -period spot rate is given by (9.10) in the same way as if we were dealing with the current one-year spot rate and implied one-year forward rates.

#### Example 9.1

The one-year cash market yield is 5.00%. Market expectations have priced one-year rates in one year's time at 5.95% and in two years' time at 7.25%. What is the current three-year spot rate that would produce these forward rate views?

To calculate this we assume an investment strategy dealing today at forward rates, and calculate the return generated from this strategy. The return after a three-year period is given by the future value relationship, which in this case is  $1.05 \times 1.0595 \times 1.0725 = 1.1931$ .

The three-year spot rate is then obtained by:

$$\left( \frac{1.1931}{1} \right)^{\frac{1}{3}} - 1 = 6.6062\%$$

**Example 9.2**

Consider the following six-month implied forward rates, when the six-month spot rate is 4.0000%:

${}_1rf_1$	4.0000%
${}_2rf_1$	4.4516%
${}_3rf_1$	5.1532%
${}_4rf_1$	5.6586%
${}_5rf_1$	6.0947%
${}_6rf_1$	7.1129%

An investor is debating between purchasing a three-year zero-coupon bond at a price of £72.79481 per £100 nominal or buying a six-month zero-coupon bond and then rolling over the investment every six months for the three-year term. If the investor was able to reinvest their proceeds every six months at the actual forward rates in place today, what would their proceeds be at the end of the three-year term?

An investment of £72.79481 at the spot rate of 4% and then reinvested at the forward rates in our table over the next three years would yield a terminal value of:

$$72.79481 \times (1.04)(1.044516)(1.051532)(1.056586)(1.060947)(1.071129) = 100.$$

This merely reflects our spot and forward rates relationship, in that if all the forward rates are indeed realised, our investor's £72.79 will produce a terminal value that matches the investment in a three-year zero-coupon bond priced at the three-year spot rate. This illustrates the relationship between the three-year spot rate, the six-month spot rate and the implied six-month forward rates. So what is the three-year zero-coupon bond trading at? Using (9.10) the solution to this is given by:

$$rs_6 = ((1.04)(1.044516)(1.051532)(1.056586)(1.060947)(1.071129))^{\frac{1}{6}} - 1 = 5.4346\%$$

which solves our three-year spot rate  $rs_6$  as 5.4346%. Of course we could have also solved for  $rs_6$  using the conventional price/yield formula for zero-coupon bonds. However, the calculation above illustrates the relationship between spot and forward rates.

**9.4.3 An important note on spot and forward rates**

Forward rates that exist at any one time reflect everything that is known in the market *up to that point*. Certain market participants may believe that the forward rate curve is a forecast of the future spot rate curve. This is implied by the *unbiased expectations hypothesis* that we consider below. In fact there is no direct relationship between the forward rate curve and the spot rate curve; for an excellent analysis of this see Jarrow (1996). It is possible, for example, for the forward rate curve to be upward sloping at the same time that short-dated spot rates are expected to decline.

To view the forward rate curve as a predictor of rates is a misuse of it. The derivation of forward rates reflects all currently known market information. Assuming that all developed

country markets are at least semi-strong form,<sup>4</sup> to preserve market equilibrium there can only be one set of forward rates from a given spot rate curve. However, this does not mean that such rates are a prediction because the instant after they have been calculated, new market knowledge may become available that alters the market's view of future interest rates. This will cause the forward rate curve to change.

Forward rates are important because they are required to make prices today for dealing at a future date. For example a bank's corporate customer may wish to fix today the interest rate payable on a loan that begins in one year from now; what rate does the bank quote? The forward rate is used by market makers to quote prices for dealing today, and is the best *expectation* of future interest rates given everything that is known in the market up to now, but it is not a prediction of future spot rates. What would happen if a bank was privy to insider information, for example it knew that central bank base rates would be changed very shortly? A bank in possession of such information (if we ignore the ethical implications) would not quote forward rates based on the spot rate curve, but would quote rates that reflected its insider knowledge.

#### 9.4.4 Bond valuation using forward rates

That there is a relationship between spot rates and implied forward rates, although it is not necessarily a straightforward one, should tell us that, in theory there is no difference in valuing a conventional bond with either spot rates or forward rates. The present value of a cash flow  $C$  received in period  $n$  using forward rates is given by (9.11):

$$PV_C = \frac{C}{(1 + rs_1)(1 + {}_1rf_1)(1 + {}_2rf_1) \dots (1 + {}_nrf_1)} \quad (9.11)$$

Therefore we use (9.11) to assemble the expression for valuing an  $N$ -period term bond using implied forward rates, with coupon  $C$ , given at (9.12). Note that we use the six-month or one-year spot rates and the six-month or one-year implied forward rates for the forward dates according to whether the bond pays annual or semi-annual coupons. Equation (9.12) assumes an exact number of interest periods to maturity.

$$P_d = \frac{C}{(1 + rs_1)} + \frac{C}{(1 + rs_1)(1 + {}_0rf_1)} + \frac{C}{(1 + rs_1)(1 + {}_1rf_1)(1 + {}_2rf_1)} + \dots \\ + \frac{C + M}{(1 + rs_1)(1 + {}_1rf_1)(1 + {}_2rf_1) \dots (1 + {}_Nrf_1)} \quad (9.12)$$

Although bond analysts may use either spot or implied forward rates to present value cash flow streams, the final valuation will be the same regardless of whichever rates are used.

<sup>4</sup> See the Preface in Choudhry, M., *The Bond and Money Markets: Strategy, Trading and Analysis* (Oxford, UK: Butterworth-Heinemann, 2001).

## 9.5 Analysing and interpreting the yield curve

From observing yield curves in different markets at any time, we notice that a yield curve can adopt one of four basic shapes, which are:

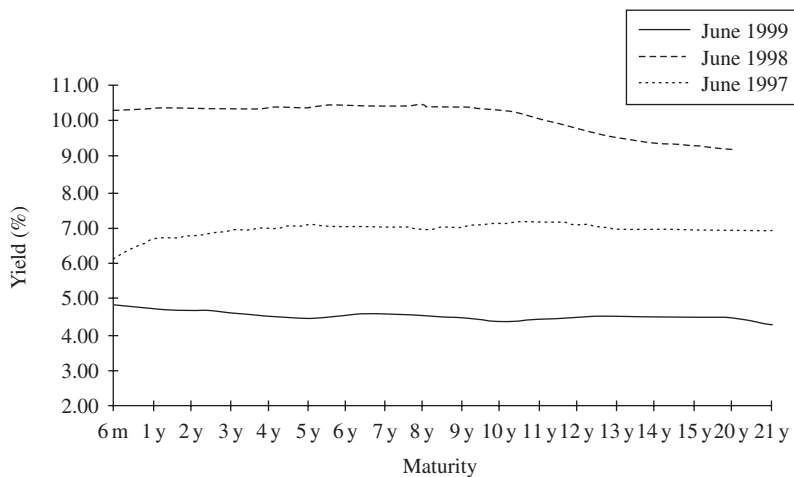
- *normal* or *conventional*: in which yields are at “average” levels and the curve slopes gently upwards as maturity increases;
- *upward sloping* or *positive* or *rising*: in which yields are at historically low levels, with long rates substantially greater than short rates;
- *downward sloping* or *inverted* or *negative*: in which yield levels are very high by historical standards, but long-term yields are significantly lower than short rates;
- *humped*: where yields are high with the curve rising to a peak in the medium-term maturity area, and then sloping downwards at longer maturities.

Sometimes yield curves will incorporate a mixture of the above features.

A great deal of effort is expended by bond analysts and economists analysing and interpreting yield curves. There is often a considerable information content associated with any curve at any time. For example Figure 9.6 shows the UK gilt redemption yield curve at three different times in the ten years from June 1989 to June 1999. What does the shape of each curve tell us about the UK debt market, and the UK economy at each particular time?

In this section we will consider the various explanations that have been put forward to explain the shape of the yield curve at any one time. None of the theories can adequately explain everything about yield curves and the shapes they assume at any time, so generally observers seek to explain specific curves using a combination of the accepted theories. This subject is a large one, indeed we could devote several books to it, so at this stage we will just introduce the main ideas.

The existence of a yield curve itself indicates that there is a cost associated with funds of different maturities, otherwise we would observe a flat yield curve. The fact that we very



**Figure 9.6:** UK gilt redemption yield curves. (Source: Bloomberg).

rarely observe anything approaching a flat yield suggests that investors require different rates of return depending on the maturity of the instrument they are holding. In this section we review the main theories that have been put forward to explain the shape of the yield curve, which all have fairly long-dated antecedents.

An excellent account of the term structure is given in *Theory of Financial Decision Making* by Jonathan Ingersoll (1987), Chapter 18. In fact it is worth purchasing this book just for Chapter 18 alone. Another quality account of the term structure is by Shiller (1990). In the following section we provide an introductory review of the research on this subject to date.

### 9.5.1 *The expectations hypothesis*

The expectations hypothesis suggests that bondholders' expectations determine the course of future interest rates. There are two main competing versions of this hypothesis, the *local expectations hypothesis* and the *unbiased expectations hypothesis*. The *return-to-maturity expectations hypothesis* and *yield-to-maturity expectations hypothesis* are also quoted (see Ingersoll 1987). The local expectations hypothesis states that all bonds of the same class but differing in term to maturity will have the same expected holding period rate of return. This suggests that a six-month bond and a twenty-year bond will produce the same rate of return, on average, over the stated holding period. So if we intend to hold a bond for six months, we will receive the same return no matter what specific bond we buy. The author feels that this theory is not always the case nor relevant, despite being mathematically neat; however, it is worth spending a few moments discussing it and related points.

Generally holding period returns from longer-dated bonds are on average higher than those from short-dated bonds. Intuitively we would expect this, with longer-dated bonds offering higher returns to compensate for their higher price volatility (risk). The local expectations hypothesis would not agree with the conventional belief that investors, being risk averse, require higher returns as a reward for taking on higher risk; in addition it does not provide any insight about the shape of the yield curve. An article by Cox, Ingersoll and Ross (1981) showed that the local expectations hypothesis best reflected equilibrium between spot and forward yields. This was demonstrated using a feature known as Jensen's inequality, which is described in Appendix 6.2 of the author's book *The Bond and Money Markets*. Robert Jarrow (1996) states

“... in an economic equilibrium, the returns on ... similar maturity zero-coupon bonds cannot be too different. If they were too different, no investor would hold the bond with the smaller return. This difference could not persist in an economic equilibrium.”

(Jarrow 1996, p. 50)

This reflects economic logic, but in practice other factors can impact on holding period returns between bonds that do not have similar maturities. For instance investors will have restrictions as to which bonds they can hold, for example banks and building societies are required to hold short-dated bonds for liquidity purposes. In an environment of economic dis-equilibrium, these investors would still have to hold shorter-dated bonds, even if the holding period return was lower.

So although it is economically neat to expect that the return on a long-dated bond is equivalent to rolling over a series of shorter-dated bonds, it is often observed that longer-term (default-free) returns exceed annualised short-term default-free returns. So an investor that continually rolled over a series of short-dated zero-coupon bonds would most likely receive a lower return than if they had invested in a long-dated zero-coupon bond. Rubinstein (1999) gives an excellent, accessible explanation of why this should be so. The reason is that compared to the theoretical model, in reality future spot rates are not known with certainty. This means that short-dated zero-coupon bonds are more attractive to investors for two reasons; first, they are more appropriate instruments to use for hedging purposes, and secondly they are more liquid instruments, in that they may be more readily converted back into cash than long-dated instruments. With regard to hedging, consider an exposure to rising interest rates. If the yield curve shifts upwards at some point in the future, the price of long-dated bonds will fall by a greater amount. This is a negative result for holders of such bonds, whereas the investor in short-dated bonds will benefit from rolling over their funds at the (new) higher rates. With regard to the second issue, Rubinstein (1999) states

“... it can be shown that in an economy with risk-averse individuals, uncertainty concerning the timing of aggregate consumption, the partial irreversibility of real investments (longer-term physical investments cannot be converted into investments with earlier payouts without sacrifice), [and]... real assets with shorter-term payouts will tend to have a ‘liquidity’ advantage.”

(Rubinstein 1999, pp. 84–85)

Therefore the demand for short-term instruments is frequently higher, and hence short-term returns are often lower than long-term returns.

The *pure or unbiased expectations hypothesis* is more commonly encountered and states that current implied forward rates are unbiased estimators of future spot interest rates.<sup>5</sup> It assumes that investors act in a way that eliminates any advantage of holding instruments of a particular maturity. Therefore if we have a positive-sloping yield curve, the unbiased expectations hypothesis states that the market expects spot interest rates to rise. Equally, an inverted yield curve is an indication that spot rates are expected to fall. If short-term interest rates are expected to rise, then longer yields should be higher than shorter ones to reflect this. If this were not the case, investors would only buy the shorter-dated bonds and roll over the investment when they matured. Likewise if rates are expected to fall then longer yields should be lower than short yields. The unbiased expectations hypothesis states that the long-term interest rate is a geometric average of expected future short-term rates. This was in fact the theory that was used to derive the forward yield curve using (9.5) and (9.6) previously. This gives us:

$$(1 + r_{s_N})^N = (1 + r_{s_1})(1 + {}_1r_{f_2}) \dots (1 + {}_{N-1}r_{f_N}) \quad (9.13)$$

or

$$(1 + r_{s_N})^N = (1 + r_{s_{N-1}})^{N-1}(1 + {}_{N-1}r_{f_N}) \quad (9.14)$$

<sup>5</sup> For original discussion, see Lutz (1940) and Fisher (1986, although he formulated his ideas earlier).

where  $rs_N$  is the spot yield on an  $N$ -year bond and  ${}_{n-1}rf_n$  is the implied one-year rate  $n$  years ahead. For example if the current one-year spot rate is  $rs_1 = 5.0\%$  and the market is expecting the one-year rate in a year's time to be  ${}_1rf_2 = 5.539\%$ , then the market is expecting a £100 investment in two one-year bonds to yield:

$$£100(1.05)(1.05539) = £110.82$$

after two years. To be equivalent to this an investment in a two-year bond has to yield the same amount, implying that the current two-year rate is  $rs_2 = 5.7\%$  as shown below:

$$£100(1 + rs_2)^2 = £110.82$$

which gives us  $rs_2$  equal to 5.27%, and gives us the correct future value as shown below:

$$£100(1.0527)^2 = £110.82.$$

This result must be so, to ensure no arbitrage opportunities exist in the market and in fact we showed as much earlier in the chapter when we considered forward rates. According to the unbiased expectations hypothesis therefore, the forward rate  ${}_0rf_2$  is an unbiased predictor of the spot rate  ${}_1rs_1$  observed one period later; on average the forward rate should equal the subsequent spot rate. The hypothesis can be used to explain any shape in the yield curve.

A rising yield curve is therefore explained by investors expecting short-term interest rates to rise, that is  ${}_1rf_2 > rs_2$ . A falling yield curve is explained by investors expecting short-term rates to be lower in the future. A humped yield curve is explained by investors expecting short-term interest rates to rise and long-term rates to fall. Expectations, or views on the future direction of the market, are a function mainly of the expected rate of inflation. If the market expects inflationary pressures in the future, the yield curve will be positively shaped, while if inflation expectations are inclined towards disinflation, then the yield curve will be negative. However, several empirical studies including one by Fama (1976) have shown that forward rates are essentially biased predictors of future spot interest rates, and often overestimate future levels of spot rates. The unbiased hypothesis has also been criticised for suggesting that investors can forecast (or have a view on) very long-dated spot interest rates, which might be considered slightly unrealistic. As yield curves in most developed country markets exist to a maturity of up to thirty years or longer, such criticisms may have some substance. Are investors able to forecast interest rates 10, 20 or 30 years into the future? Perhaps not. Nevertheless this is indeed the information content of say, a thirty-year bond; since the yield on the bond is set by the market, it is valid to suggest that the market has a view on inflation and future interest rates for up to thirty years forward.

The expectations hypothesis is stated in more than one way; we have already encountered the local expectations hypothesis. Other versions include the *return-to-maturity* expectations hypothesis, which states that the total return from holding a zero-coupon bond to maturity will be equal to the total return that is generated by holding a short-term instrument and continuously rolling it over the same maturity period. A related version, the *yield-to-maturity* hypothesis, states that the periodic return from holding a zero-coupon bond will be equal to the return from rolling over a series of coupon bonds, but refers to the annualised return earned each year rather than the total return earned over the life of the bond. This assumption enables a zero-coupon yield curve to be derived from the redemption yields of coupon bonds. The unbiased expectations hypothesis states that forward rates

are equal to the spot rates expected by the market in the future. The Cox-Ingersoll-Ross article suggests that only the local expectations hypothesis describes a model that is purely arbitrage-free, as under the other scenarios it would be possible to employ certain investment strategies that would produce returns in excess of what was implied by today's yields. Although it has been suggested<sup>6</sup> that the differences between the local and the unbiased hypotheses are not material, a model that describes such a scenario would not reflect investors' beliefs, which is why further research is ongoing in this area.

The unbiased expectations hypothesis does not by itself explain all the shapes of the yield curve or the information content contained within it, so it is often tied in with other explanations, including the liquidity preference theory.

### 9.5.2 *Liquidity preference theory*

Intuitively we might feel that longer maturity investments are more risky than shorter ones. An investor lending money for a five-year term will usually demand a higher rate of interest than if they were to lend the same customer money for a five-week term. This is because the borrower may not be able to repay the loan over the longer time period as they may, for instance, have gone bankrupt in that period. For this reason longer-dated yields should be higher than short-dated yields, to recompense the lender for the higher risk exposure during the term of the loan.<sup>7</sup>

We can consider this theory in terms of inflation expectations as well. Where inflation is expected to remain roughly stable over time, the market would anticipate a positive yield curve. However, the expectations hypothesis cannot by itself explain this phenomenon, as under stable inflationary conditions one would expect a flat yield curve. The risk inherent in longer-dated investments, or the *liquidity preference theory*, seeks to explain a positive shaped curve. Generally borrowers prefer to borrow over as long a term as possible, while lenders will wish to lend over as short a term as possible. Therefore, as we first stated, lenders have to be compensated for lending over the longer term; this compensation is considered a premium for a loss in *liquidity* for the lender. The premium is increased the further the investor lends across the term structure, so that the longest-dated investments will, all else being equal, have the highest yield. So the liquidity preference theory states that the yield curve should almost always be upward sloping, reflecting bondholders' preference for the liquidity and lower risk of shorter-dated bonds. An inverted yield curve could still be explained by the liquidity preference theory when it is combined with the unbiased expectations hypothesis. A *humped* yield curve might be viewed as a combination of an inverted yield curve together with a positive-sloping liquidity preference curve.

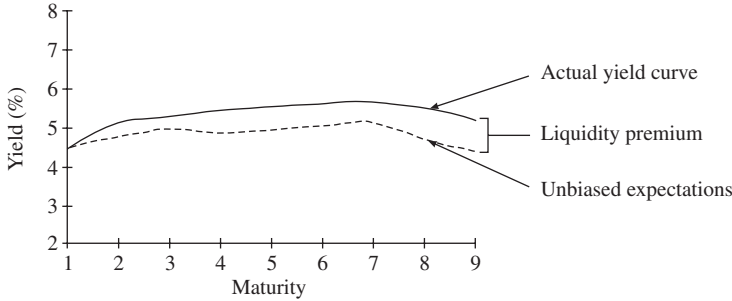
The difference between a yield curve explained by unbiased expectations and an actual observed yield curve is sometimes referred to as the *liquidity premium*. This refers to the fact that in some cases short-dated bonds are easier to transact in the market than long-term bonds. It is difficult to quantify the effect of the liquidity premium, which in any case is not static and fluctuates over time. The liquidity premium is so called because, in order to induce investors to hold longer-dated securities, the yields on such securities must be higher than those available on short-dated securities, which are more liquid and may be

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<sup>6</sup> For example, see Campbell (1986) and Livingstone (1990).

<sup>7</sup> For original discussion, see Hicks (1946).





**Figure 9.7:** Yield curve explained by expectations hypothesis and liquidity preference.

converted into cash more easily. The liquidity premium is the compensation required for holding less liquid instruments. If longer-dated securities then provide higher yields, as is suggested by the existence of the liquidity premium, they should generate on average higher total returns over an investment period. This is not consistent with the local expectations hypothesis. More formally we can write:

$$0 = L_1 < L_2 < L_3 < \dots < L_n \text{ and } (L_2 - L_1) > (L_3 - L_2) > \dots > (L_n - L_{n-1})$$

where  $L_n$  is the premium for a bond with term to maturity of  $n$  years, which states that the premium increases as the term to maturity rises and that an otherwise flat yield curve will have a positively sloping curve, with the degree of slope steadily decreasing as we extend along the yield curve. This is consistent with observation of yield curves under “normal” conditions.

The expectations hypothesis assumes that forward rates are equal to the expected future spot rates, that is as shown in (9.15):

$${}_{n-1}rf_n = E({}_{n-1}rs_n) \tag{9.15}$$

where  $E({}_{n-1}rs_n)$  is the expectations operator for the current period. This assumption implies that the forward rate is an unbiased predictor of the future spot rate, as we suggested in the previous paragraph. Liquidity preference theory on the other hand, recognises the possibility that the forward rate may contain an element of liquidity premium which declines over time as the period approaches, given by (9.16):

$${}_{n-1}rf_n > E({}_{n-1}rs_n) \tag{9.16}$$

If there was uncertainty in the market about the future direction of spot rates and hence where the forward rate should lie, (9.16) is adjusted to give the reverse inequality.

### 9.5.3 Money substitute hypothesis

A particular explanation of short-dated bond yield curves has been attempted by Kessel (1965). In the *money substitute* theory short-dated bonds are regarded as substitutes for holding cash. Investors hold only short-dated market instruments because these are viewed as low or negligible risk. As a result the yields of short-dated bonds are depressed due to the

increased demand and lie below longer-dated bonds. Lenders on the other hand prefer to issue debt for longer maturities, and on as few occasions as possible to minimise costs. Therefore the yields of longer-dated paper are driven upwards due to a combination of increased supply and lower liquidity. In certain respects the money substitute theory is closely related to the liquidity preference theory, and by itself does not explain inverted or humped yield curves.

#### 9.5.4 *Segmentation hypothesis*

The capital markets are made up of a wide variety of users, each with different requirements. Certain classes of investors will prefer dealing at the short end of the yield curve, while others will concentrate on the longer end of the market. The *segmented markets* theory suggests that activity is concentrated in certain specific areas of the market, and that there are no interrelationships between these parts of the market; the relative amounts of funds invested in each of the maturity spectra causes differentials in supply and demand, which results in humps in the yield curve. That is, the shape of the yield curve is determined by supply and demand for certain specific maturity investments, each of which has no reference to any other part of the curve.

For example, banks and building societies concentrate a large part of their activity at the short end of the curve, as part of daily cash management (known as *asset and liability management*) and for regulatory purposes (known as *liquidity* requirements). Fund managers such as pension funds and insurance companies are active at the long end of the market. Few institutional investors, however, have any preference for medium-dated bonds. This behaviour on the part of investors will lead to high prices (low yields) at both the short and long ends of the yield curve and lower prices (higher yields) in the middle of the term structure.

Since according to the segmented markets hypothesis a separate market exists for specific maturities along the term structure, interest rates for these maturities are set by supply and demand.<sup>8</sup> Where there is no demand for a particular maturity, the yield will lie above other segments. Market participants do not hold bonds in any other area of the curve outside their area of interest<sup>9</sup> so that short-dated and long-dated bond yields exist independently of each other. The segmented markets theory is usually illustrated by reference to banks and life companies. Banks and building societies hold their funds in short-dated instruments, usually no longer than five years in maturity. This is because of the nature of retail banking operations, with a large volume of instant access funds being deposited at banks, and also for regulatory purposes. Holding short-term, liquid bonds enables banks to meet any sudden or unexpected demand for funds from customers. The classic theory suggests that as banks invest their funds in short-dated bonds, the yields on these bonds are driven down. When they then liquidate part of their holding, perhaps to meet higher demand for loans, the yields are driven up and prices of the bonds fall. This affects the short end of the yield curve but not the long end.

The segmented markets theory can be used to explain any particular shape of the yield curve, although it fits best perhaps with positive sloping curves. However, it cannot be used

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<sup>8</sup> See Culbertson (1957).

<sup>9</sup> For example, retail and commercial banks hold bonds in the short dates, while life assurance companies hold long-dated bonds.

to interpret the yield curve whatever shape it may be, and therefore offers no information content during analysis. By definition the theory suggests that for investors, bonds with different maturities are not perfect substitutes for each other. This is because different bonds would have different holding period returns, making them imperfect substitutes of one another.<sup>10</sup> As a result of bonds being imperfect substitutes, markets are segmented according to maturity.

The segmentations hypothesis is a reasonable explanation of certain features of a conventional positively-sloping yield curve, but by itself is not sufficient. There is no doubt that banks and building societies have a requirement to hold securities at the short end of the yield curve, as much for regulatory purposes as for yield considerations, however other investors are probably more flexible and will place funds where value is deemed to exist. Nonetheless the higher demand for benchmark securities does drive down yields along certain segments of the curve.

A slightly modified version of the market segmentation hypothesis is known as the *preferred habitat theory*. This suggests that different market participants have an interest in specified areas of the yield curve, but can be induced to hold bonds from other parts of the maturity spectrum if there is sufficient incentive. Hence banks may, at certain times, hold longer-dated bonds once the price of these bonds falls to a certain level, making the return on the bonds worth the risk involved in holding them. Similar considerations may persuade long-term investors to hold short-dated debt. So higher yields will be required to make bondholders shift out of their usual area of interest. This theory essentially recognises the flexibility that investors have, outside regulatory or legal requirements (such as the terms of an institutional fund's objectives), to invest in whatever part of the yield curve they identify value.

### **9.5.5 *Humped yield curves***

When plotting a yield curve of all the bonds in a certain class, it is common to observe humped yield curves. These usually occur for a variety of reasons. In line with the unbiased expectations hypothesis, humped curves will be observed when interest rates are expected to rise over the next several periods and then decline. On other occasions humped curves can result from skewed expectations of future interest rates. This is when the market believes that fairly constant future interest rates are likely, but also believes that there is a small probability for lower rates in the medium term. The other common explanation for humped curves is the preferred habitat theory.

### **9.5.6 *The combined theory***

The explanation for the shape of the yield curve at any time is more likely to be described by a combination of the pure expectations hypothesis and the liquidity preference theory, and possibly one or two other theories. Market analysts often combine the unbiased expectations hypothesis with the liquidity preference theory into an "eclectic" theory. The result is fairly consistent with any shape of yield curve, and is also a predictor of rising interest rates.

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<sup>10</sup> *Ibid.*

In the combined theory the forward interest rate is equal to the expected future spot rate, together with a quantified liquidity premium. This is shown at (9.17):

$${}_0rf_i = E({}_{i-1}rs_1) + L_i \quad (9.17)$$

where  $L_i$  is the liquidity premium for a term to maturity of  $i$ . The size of the liquidity premium is expected to increase with increasing maturity.<sup>11</sup>

The combined theory is consistent with an inverted yield curve. This will apply even when the liquidity premium is increasing with maturity, for example where the expected future spot interest rate is declining. Typically this would be where there was a current term structure of falling yields along the term structure. The spot rates might be declining where the fall in the expected future spot rate exceeds the corresponding increase in the liquidity premium.

### 9.5.7 *The flat yield curve*

The conventional theories do not seek to explain a flat yield curve. Although it is rare to observe flat curves in a market, certainly for any length of time, at times they do emerge in response to peculiar economic circumstances. In the conventional thinking, a flat curve is not tenable because investors should in theory have no incentive to hold long-dated bonds over shorter-dated bonds when there is no yield premium, so that as they sell off long-dated paper the yield at the long end should rise, producing an upward sloping curve. In previous circumstances of a flat curve, analysts have produced different explanations for their existence. In November 1988 the US Treasury yield curve was flat relative to the recent past; researchers contended that this was the result of the market's view that long-dated yields would fall as bond prices rallied upwards.<sup>12</sup> One recommendation is to buy longer maturities when the yield curve is flat, in anticipation of lower long-term interest rates, which is the direct opposite to the view that a flat curve is a signal to sell long bonds. In the case of the US market in 1988, long bond yields did in fact fall by approximately 2% in the following 12 months. This would seem to indicate that one's view of future long-term rates should be behind the decision to buy or sell long bonds, rather than the shape of the yield curve itself. A flat curve may well be more heavily influenced by supply and demand factors than anything else, with the majority opinion eventually winning out and forcing a change in the curve to a more conventional shape.

### 9.5.8 *Further views on the yield curve*

In this and the previous chapters our discussion of present values, spot and forward interest rates assumed an economist's world of the *perfect market* (also sometimes called the *frictionless* financial market). Such a perfect capital market is characterised by:

- perfect information;
- no taxes;
- bullet maturity bonds;
- no transaction costs.

<sup>11</sup> So that  $L_i > L_{i-1}$ .

<sup>12</sup> See Levy (1999).

Of course in practice markets are not completely perfect. However, assuming perfect markets makes the discussion of spot and forward rates and the term structure easier to handle. When we analyse yield curves for their information content, we have to remember that the markets that they represent are not perfect, and that frequently we observe anomalies that are not explained by the conventional theories.

At any one time it is probably more realistic to suggest that a range of factors contributes to the yield curve being one particular shape. For instance short-term interest rates are greatly influenced by the availability of funds in the money market. The slope of the yield curve (usually defined as the 10-year yield minus the three-month interest rate) is also a measure of the degree of tightness of government monetary policy. A low, upward sloping curve is often thought to be a sign that an environment of cheap money, due to a more loose monetary policy, is to be followed by a period of higher inflation and higher bond yields. Equally a high downward sloping curve is taken to mean that a situation of tight credit, due to more strict monetary policy, will result in falling inflation and lower bond yields. Inverted yield curves have often preceded recessions; for instance *The Economist* in an article from April 1998 remarked that in the United States every recession since 1955 bar one had been preceded by a negative yield curve. The analysis is the same: if investors expect a recession they also expect inflation to fall, so the yields on long-term bonds will fall relative to short-term bonds. So the conventional explanation for an inverted yield curve is that the markets and the investment community expect either a slow-down of the economy, or an outright recession.<sup>13</sup> In this case one would expect the monetary authorities to ease the money supply by reducing the base interest rate in the near future: hence an inverted curve. At the same time, a reduction of short-term interest rates will affect short-dated bonds and these are sold off by investors, further raising their yield.

While the conventional explanation for negative yield curves is an expectation of economic slow-down, on occasion other factors will be involved. In the UK in the period July 1997–June 1999 the gilt yield curve was inverted.<sup>14</sup> There was no general view that the economy was heading for recession however, in fact the new Labour government led by Tony Blair inherited an economy believed to be in good health. Instead the explanation behind the inverted shape of the gilt yield curve focused on two other factors: first, the handing of responsibility for setting interest rates to the Monetary Policy Committee (MPC) of the Bank of England, and secondly the expectation that the UK would over the medium term, abandon sterling and join the euro currency. The yield curve in this time suggested that the market expected the MPC to be successful and keep inflation at a level around 2.5% over the long term (its target is actually a 1% range either side of 2.5%), and also that sterling interest rates would need to come down over the medium term as part of *convergence* with interest rates in euroland. These are both medium-term expectations however, and in the author's view not logical at the short-end of the yield curve. In fact the term structure moved to a positive-sloped shape up to the 6–7 year area, before inverting out to the long-

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<sup>13</sup> A recession is formally defined as two successive quarters of falling output in the domestic economy.

<sup>14</sup> Although the curve briefly went positively sloped out to 7–8 years in July 1999, it very quickly reverted to being inverted throughout the term structure, and remained so at the time of writing.

end of the curve, in June 1999. This is a more logical shape for the curve to assume, but it was short-lived and returned to being inverted after the two-year term.

There is therefore significant information content in the yield curve, and economists and bond analysts will consider the shape of the curve as part of their policy making and investment advice. The shape of parts of the curve, whether the short-end or long-end, as well as that of the entire curve, can serve as useful predictors of future market conditions. As part of an analysis it is also worthwhile considering the yield curves across several different markets and currencies. For instance the interest-rate swap curve, and its position relative to that of the government bond yield curve, is also regularly analysed for its information content. In developed country economies the swap market is invariably as liquid as the government bond market, if not more liquid, and so it is common to see the swap curve analysed when making predictions about say, the future level of short-term interest rates.

Government policy will influence the shape and level of the yield curve, including policy on public sector borrowing, debt management and open-market operations. The market's perception of the size of public sector debt will influence bond yields; for instance an increase in the level of debt can lead to an increase in bond yields across the maturity range. Open-market operations, which refers to the daily operation by the Bank of England to control the level of the money supply (to which end the Bank purchases short-term bills and also engages in repo dealing), can have a number of effects. In the short-term it can tilt the yield curve both upwards and downwards; longer term, changes in the level of the base rate will affect yield levels. An anticipated rise in base rates can lead to a drop in prices for short-term bonds, whose yields will be expected to rise; this can lead to a temporary inverted curve. Finally debt management policy will influence the yield curve. (In the United Kingdom this is now the responsibility of the Debt Management Office.) Much government debt is rolled over as it matures, but the maturity of the replacement debt can have a significant influence on the yield curve in the form of humps in the market segment in which the debt is placed, if the debt is priced by the market at a relatively low price and hence high yield.

### **Example 9.3**

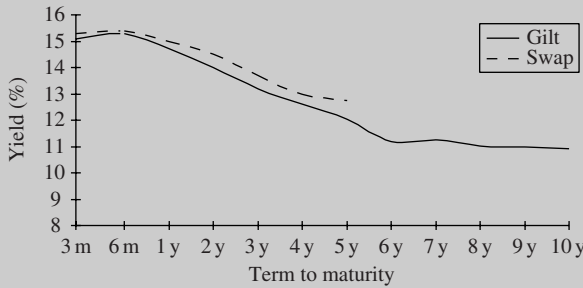
#### **The information content of the UK gilt curve: a special case**

In the first half of 1999 various factors combined to increase the demand for gilts, especially at the long-end of the yield curve, at a time of a reduction in the supply of gilts as the government's borrowing requirement was falling. This increased demand led to a lowering in market liquidity as prices rose and gilts became more expensive (that is, lower yielding) than government securities in most European countries. This is a relatively new phenomenon, witness 10-year UK government yields at 5.07% compared to US and German at 6.08% and 5.10% respectively at one point in August 1999.<sup>15</sup> At the long end of the yield curve, UK rates were, for the first time in over 30 years, below both German and US yields, reflecting the market's positive long-term view of the UK economy. At the end of September 1999, the German 30-year bond (the 4¾%

<sup>15</sup> Yields obtained from Bloomberg.

<sup>16</sup> *Ibid.*

July 2028) was yielding 5.73% and the US 6.125% 2027 was at 6.29%, compared to the UK 6% 2028, which was trading at a yield of 4.81%.<sup>16</sup>



**Figure 9.8:** UK gilt and swap yield curves. (Source: BoE).

The relative dearth of UK gilts was reflected in the yield spread of interest-rate swaps versus gilts. For example in March 1999 10-year swap spreads over government bonds were over 80 basis points in the UK compared to 40 basis points in Germany. This was historically large and was more than what might be required to account purely for the credit risk of swaps. It appears that this reflected the high demand for gilts, which had depressed the long end of the yield curve. At this point the market contended that the gilt yield curve no longer provided an accurate guide to expectations about future short-term interest rates. The sterling swap market, where liquidity is always as high as the government market and (as on this occasion) often higher, was viewed as being a more accurate prediction of future short-term interest rates. In hindsight this view turned out to be correct; swap rates fell in the UK in January and February 1999, and by the end of the following month the swap yield curve had become slightly upward-sloping, whereas the gilt yield curve was still inverted. This does indeed suggest that the market foresaw higher future short-term interest rates and that the swap curve predicted this, while the gilt curve did not. Figure 9.8 shows the change in the swap yield curve to a more positive slope from December 1998 to March 1999, while the gilt curve remained inverted. This is an occasion when the gilt yield curve’s information content was less relevant than that in another market yield curve, due to the peculiar circumstances resulting from lack of supply to meet increased demand.

## 9.6 Interpreting the yield curve

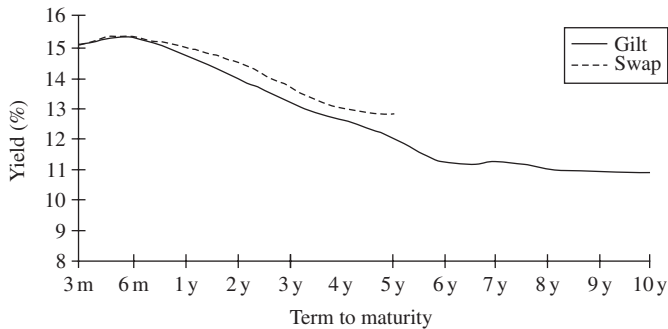
We illustrate some of the points we have raised here using yield curves from the United Kingdom gilt market during the 1990s. It is easier to analyse them for their information content in hindsight than it might have been at the time, but these observations illustrate the general conclusions that might be made.

<sup>16</sup> *Ibid.*

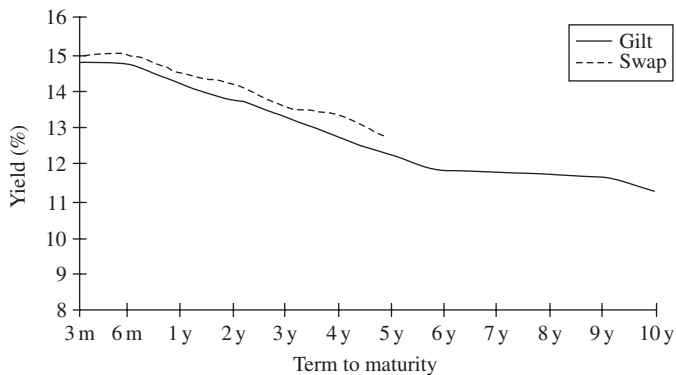
To begin, consider the observed yield curves for January and June 1990 in Figures 9.9 and 9.10.<sup>17</sup>

The yield curve for the first date suggests declining short-term rates and this is indicated by the yield curve for June 1990. The prediction is approximately accurate.

That the yield curves were inverted is not surprising given that the UK economy was shortly to enter an economic recession, however at that date – January 1990 – it had not yet begun. The evidence of GDP output data is that the recession took place during 1990–91. The markets were therefore expecting some loosening of monetary policy given the economic slow-down during 1989. There was an additional anomaly in that during 1988 the government had been paying off public sector debt, leading some commentators to suggest



**Figure 9.9:** January 1990.



**Figure 9.10:** June 1990.

<sup>17</sup> All government yield curves shown are fitted par yield curves, using the Bank of England's internal model (see Mastronikola (1991) and Anderson and Sleath (1999)), except where indicated. Source data is the Bank of England. The other curve is the interest-rate swap curve, also called the Libor curve, for sterling swaps. In practice interest-rate swaps are priced off the government yield curve, and reflect the market's view of interbank credit risk, as the swap rate is payable by a bank (or corporate) viewed as having an element of credit risk. All swap curves are drawn using interest data from Bloomberg.



that gilt supply would be reduced in coming years. This may have contributed to the depressed yields at the long end in January 1990 but almost certainly had less influence in June 1990, when the recession was underway.

Consider the same curves for June 1991 and January 1992, shown as Figures 9.11 and 9.12 respectively. In this case the money market has priced swaps to give a different shaped yield curve; does this mean that the money market has a different view of forward rates to government bond investors? Observing the yield curves for January 1992 suggests not: the divergence in the swap curve reflects credit considerations that price long maturity corporate rates at increasing yield spreads. This is common during recessions, and indeed the curves reflect recession conditions in the UK economy at the time, as predicted by the yield curves during 1990. Another indicator is the continuation of the wide swap spread as the term to maturity increases to ten years, rather than the conventional mirroring of the government curve. Note also that the short-term segment of the swap curve in June 1991 (Figure 9.11) matches the government yield curve, indicating that the market agreed with the short-term forward rate prediction of the government curve.

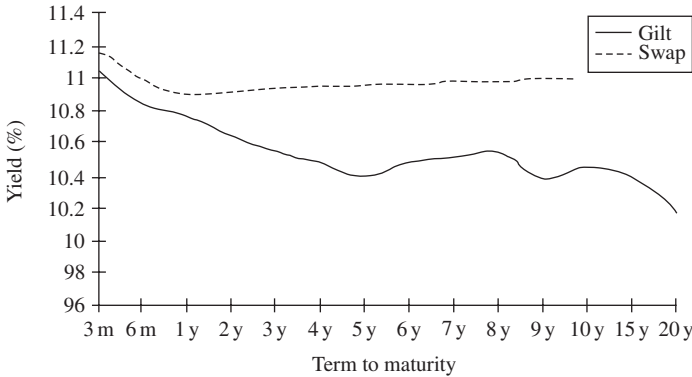


Figure 9.11: June 1991.

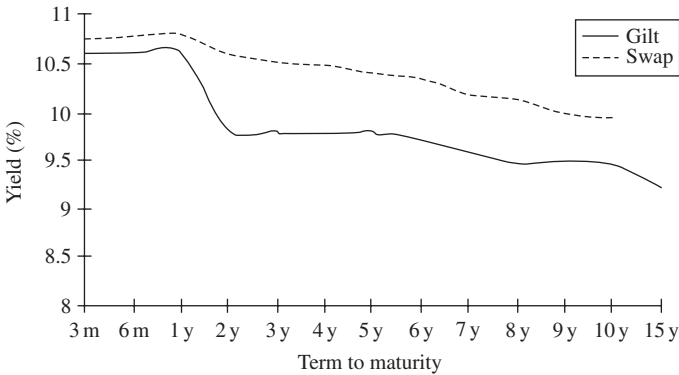
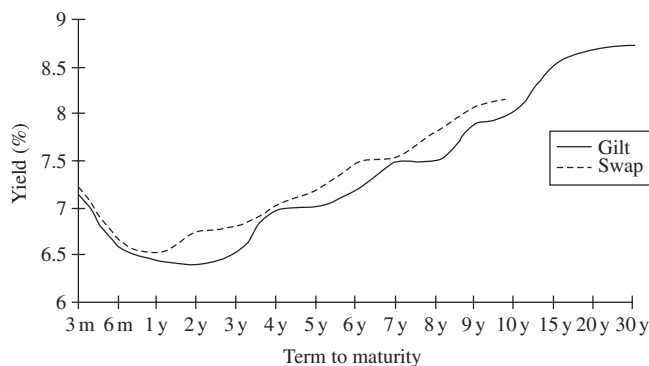


Figure 9.12: January 1992.



**Figure 9.13:** November 1992.

During 1992 as the UK economy came out of recession the government yield curve changed from inverted to steadily positive, while the swap curve mirrored the shape of the government curve. The swap spread itself has declined, to no more than 10 basis points at the short end. This was most pronounced shortly after sterling fell out of the European Union's exchange rate mechanism, shown in Figure 9.13 (curves for 5 November 1992).

Both yield curves had reverted to being purely positive sloping by January 1993.

The illustrations used are examples where government yield curves were shown to be accurate predictors of the short-term rates that followed, more so than the swap curve. This is to be expected: the government or *benchmark* yield curve is the cornerstone of the debt markets, and is used by the market to price all other debt instruments, including interest-rate swaps. This reflects both the liquidity of the government market and its risk-free status.

## 9.7 The DMO's yield curve model

An accessible account of the yield curve model used by the UK Debt Management Office is given in chapter 6 of the DMO's *Gilt Review* for 1999/2000, which can be obtained direct from the DMO.

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I don't like you, but I love you,  
Seems that I'm always thinking of you  
Oh oh oh you treat me badly,  
I love you madly...

I don't want you, but I need you,  
Don't want to kiss you, but I need to,  
Oh oh oh you do me wrong now,  
My love is strong now...

– William “Smokey” Robinson,  
*You Really Got A Hold On Me* 1963

# 10 The Art of Government Bond Trading

On a day back in early 1992, at the offices of a well known UK house, I sat on the gilt-trading desk minding my own business, just consuming the remnants of a desk lunch (which incidentally should put paid to the rumours concerning the four hour liquid lunches enjoyed by all GEMM traders!). My quiet but otherwise perfect day was then rudely interrupted by a colleague from the swaps desk introducing what seemed to be the hundredth “graduate trainee” of the month (the company liked to pride itself on its record of take-ups on the graduate front!). Although I had managed to duck the previous entrants, it appeared now that my luck had run out.

This chap had made the entrance fee by achieving a degree in something called *Fluid Dynamics*, a new one on me but one that I'm sure made him a perfect candidate for the fixed income markets. Try as I might, there appeared to be absolutely no chance of getting out of this little chore, even my tried and trusted method that I affectionately call “fugitive fantasy fear” (the art of deflecting direct questions, ultimately wearing down those seeking knowledge of you until they become bored to the point of distraction or they surrender in total frustration!) was having little impact on this obtuse fellow. And so, inevitably, I settled back for the typical deluge of questions. However, after the usual fare, one question managed to spark my imagination and had me sitting up and reminiscing my own origins within the markets:

“What does it take to make a great trader?”

My initial response was:

“Well, for starters, don't sit next to me!”

I then suggested that he was talking to the wrong person and that perhaps he should wait until my colleague Alex Miller returned from a meeting that he was chairing. Alex is a man that I amongst many, many others considered to be one of the finest traders out there.

He was also the person that taught me most of what I know today, although whether that statement does him any justice is open to debate. Alex has the skill, the knowledge and perhaps as equally important the humour, to trade what at times can be an incredibly perverse trading environment: the gilt-edged market. To him the market was something organic; he felt the very pulse of it the way an old sea captain instinctively knows the lie of the sea; he sensed the strengths and weaknesses of the opposition the way a hardened gambler picks up on the psychological subtleties that betray the potency of an opponent's hand. All this quite remarkable given the anonymity of the marketplace. The learning curve was, as in most aspects of the financial markets, at times steep but with Alex at the helm it always made for an interesting journey. At moments it was literally like trying to learn a different language: for instance, bonds took on various monikers; those maturing in 2000 were known as "Greeks" (after a hair product called Grecian 2000!) – 13% 2000s and 9% 2000s being known respectively as "Big Greeks" and "Baby Greeks". Gilts maturing in the same year but issued more recently became known rather crudely as the "Foetus Greeks"! It was all starting to get a tad out of hand when one of my broker lines squealed into action with a price in the "Colchester's", 8% 2002/06s – 0206 being the old dialling code for Colchester! (Sadly the author of this little gem, Clive Bryce, is no longer with us...)

To Alex the market was occasionally "a bit Rachel", after the famous ladies cricketer Rachel Hayhoe-Flint. Which in time I grew to understand as meaning that it had turned bullish as in "Hey ho! this market's going higher" if you can follow that perverse logic. On the other hand it could possibly have turned "a little Brothers" (Grim – intentional misspelling). Moorad's first trading mentor, on the UK sterling debentures desk, spoke about certain stocks being as rare as "rocking horse manure", or the market being as firm as a "bishop's ... finger." One can easily see why it could take quite a while to become fully cognisant with the various nuances that a newcomer to the gilt market had to encounter!

However for all the humour, Alex took the business of making money very seriously and was an amazing mentor to learn from. At times he'd be so caught up in the flow of the market that he would be oblivious to one's attempts to question him. He would often furnish the answer to a question long after the questioner had forgotten the enquiry! A finer teacher one could not find and I owe him an enormous debt to this day. Alex Miller retired at the tender age of 37, missing his intended target by just two years. I believe this is a fitting testament to just how good a trader he was!

Another person who could do the question full justice would be Nicolas Themistocli, otherwise known as "Stav", a person that I also feel enormously indebted to. I was under Nic's tutelage when I first began my trading career. His approach was cerebral, analytical and although different to Alex's, it was also very, very successful. Nic would run me through various strategies time and time again, have me pore over endless mathematical equations until they almost became second nature and I would even see them in my sleep! Above all though, he never forgot to have fun; there is a certain Managing Director that I would imagine to this day never understood quite why his office was so "damp" one cold morning in February, my only hope is that he is not reading this right now!

Nic really took me under his wing so to speak and my advancement became his personal mission. I still have a book which he gave me that proved invaluable in those early days, called *The Tao Jones Averages: A Guide to Whole-Brained Investing* by Bennett W. Goodspeed. At the time of writing, this book is out of print but if you can track down a copy it would be well worth the effort to read. One particularly interesting chapter that had inspired

me was on the subject of what Goodspeed calls *Yaqui Investing*, so I now endeavoured to pass its wisdom on to my persistent enquirer. In this chapter the author refers to another fine book by Carlos Castaneda, *The Teachings of Don Juan: A Yaqui Way of Knowledge*. Castaneda outlines Don Juan's description of the four enemies that one must overcome to become a "man of knowledge" and Goodspeed magnificently relates these to the art of becoming a wise investor, or in this case a good trader.

The first enemy or hurdle to overcome is **Fear**. If one avoids investing or trading out of fear then nothing will happen except that no knowledge will be gained. It's the old adage that a man that never made a mistake never made anything. You can read many books about the theory of trading but unless you become a player you never really learn. One can only truly "know" the different investment techniques by getting involved with them, that is how one best acquires a "feel" for the markets. It is all too easy for the inexperienced newcomer to the markets to succumb to fear.

Fear is overcome by **Clarity** and this is gained with the aforementioned experience, but unfortunately this then becomes the second enemy to the trader. Clarity of mind about how to trade, which is hard to obtain, dispels fear, but at the same time can blind. It stops one from doubting oneself and gives that person the false assurance that one can do no wrong, as everything is seen so clearly. If you yield to this power, which is only a point before your eyes, you have succumbed to your second enemy. If there is one thing that I have learnt over my years as a trader it is this: what costs the most in terms of profit and loss is not what you took into account but rather the variables that you never questioned. In other words, expect the unexpected. A good trader uses clarity only to see and analyses carefully before rushing in. It must be understood that one's clarity is almost an illusion. It is dangerous to feel too secure.

One who overcomes clarity possesses **Power**, but of course this too is an enemy. As Goodspeed so succinctly puts it, one who is defeated by this third enemy dies without really knowing how to handle it. To conquer power you have to defy it deliberately, in other words, one must not abuse this status nor become corrupted by it. So many times throughout my career have I seen people who obtain "power" but then allow it to consume them to the extent where they feel they can do no wrong. They try to use their power to exonerate them from all failings but often are found out. It can take time for this to occur but rest assured, the market can be a great leveller and does not suffer fools gladly.

The fourth enemy to becoming a good trader is **Old Age**, where one must resist the unyielding desire to rest. In the trading environment, old age does not relate to physical age, and there are many examples in the marketplace today that prove this point convincingly. No, in this instance old age relates to a tiring concentration. A time when one ceases to question the way the markets are changing and in turn fails to adapt accordingly. It is dangerous to give in to old age because you need to be constantly aware in order to maintain power over your particular sector or portfolio in what can be an everchanging world. Within this world of constantly changing parameters one thing is certain; the need for study is key, our learning requirements offer us no respite. I have witnessed many changes within the markets as participants endeavour to out-think one another in the search for profit. Then, as various trading strategies and techniques were exploited to the full, the search would continue on to more complex ones, and so on. Here it can clearly be seen that if one gives in to "the unyielding desire to rest" the result will be a falling out of step with the ongoing nature of the markets. So, for old age also read "lazy"! If you have got



to the stage where this fourth enemy comes into play then the opportunity for the bluff is attractive, but once again beware, this will only fool for a certain period of time before this ploy becomes totally transparent! It is vital to be ever flexible and willing to undergo the required further education to stay ahead and successfully navigate through the markets.

As I acquainted my new graduate friend with the other areas around the trading floor that at some point he would visit, I told him to watch and learn from the different styles and personalities that he would meet along the way. I briefly described some that I had encountered, explaining that an awareness of them would allow him to avoid the pitfalls.

Alex and Nic were extremely disciplined traders. They had their own systems and modus operandi and followed them with discipline. They remained focused and yet to watch them one would say that they looked almost relaxed. They never rushed to take a profit on a trade but at the same time were disciplined enough to cut a loss as soon as they realised the justification for the trade was wrong. As Alex was fond of saying "It's that old Rod Stewart song 'H'; *The First Cut is the Cheapest!*" Both were also confident enough in their own abilities to appreciate that a loss does not make one a loser and viewed the cutting of such losses as the sensible way to permit them to re-focus and start thinking clearly again without distraction. However, there were traders around them that unfortunately lacked that same self-confidence. These traders doubted themselves and found it difficult to execute or close out trades at the appropriate time and the resultant losses, be they actual impacts on the P&L or the missing of opportunities, would further damage their convictions. It would become a difficult spiral to break out of. Others refused to take responsibility for their own actions, every loss would be someone or something else's fault; they would blame their systems for being imperfect, they would blame their brokers for bad fills or even for picking up the phone too slowly. That said, I'm sure most traders have been guilty of this last point at some time or another!

There were some traders that blamed themselves. I have met some in my time that verged on total paranoia. They felt that the market was out to get them and felt constantly victimised. They would become almost superstitious in their trading styles. Some tripped up from being overly optimistic, to the point where mistakes were overlooked and never learnt from. Their approach would be "Oh well at least it's the bank's money, I'll make it back and more tomorrow", as if somehow by doing exactly the same as they did today, they would obtain a different result the next day! Some were trading purely for the thrill of it, like hardened gamblers. Money to them was merely a by-product, and risk and reward analysis would rarely even enter the equation. They were in the markets for the "buzz" and excitement and their main desire was to be seen as "a Player". These were often nicknamed "Glory Boys". At the other end of the scale there were those who became slaves of the first of Don Juan's aforementioned "enemies", namely **Fear**. They would enter a trade but panic at the first sight of a profit and take it much too soon. Their whole trading strategy was based on one of timidity.

To better understand Mr Fluid Dynamics' personality, I enquired as to *his* motivation and what goals he wanted to achieve within the trading environment. These two go hand in hand, for without specific goals it becomes almost impossible to be fully motivated and extremely easy to lose the plot. I explained how I felt that he needed to incorporate those goals to ensure actions that avoid all the consequences mentioned above. For instance, if he found himself blaming others for his mistakes, he needed to assess what *he* did when trading. To become more self-responsible and focused on *his* system, he should take

control of his own destiny in becoming a good trader. If he found himself increasingly trading with fear, then he would need to find clarity through learning and begin to trust his instincts more. It hardly needed explaining that failure to adapt would lead to greater levels of stress, with its detrimental effect on one's health. This in turn can easily lead to a loss of motivation. I have seen people reduced to nervous wrecks by not properly analysing and correcting bad trading practices. In this field of work a certain amount of stress is inevitable but it is down to how one deals with it that counts. You need to identify the cause of the stress, be it running positions for too long or failing to fully scrutinise the risk profile of each scenario and make a commitment to ensuring that these things don't occur in the future. Take a timeout – Alex would insist that I went out at lunchtime regardless of whether I had any plans or not. He felt that one needed to take a breather and clear the mind so that on return the necessary focus would be the better for it. At the end of the day, what use is success without the health to enjoy it?

As our time together drew to a close, the graduate thanked me for my input and motioned towards an old poem that I had taped above my broker screens. It was beginning to look a little the worse for wear but as far as I was concerned the sentiments could not be diminished regardless of how the words faded. It was another essential piece of reading given to me by Nic, and I think it entirely appropriate for anyone embarking on a career in trading.

If you can keep your head when all about you  
Are losing theirs and blaming it on you,  
If you can trust yourself when all men doubt you  
But make allowance for their doubting too,  
If you can wait and not be tired by waiting,  
Or being lied about, don't deal in lies,  
Or being hated, don't give way to hating,  
And yet don't look too good, nor talk too wise.

If you can dream – and not make dreams your master,  
If you can think – and not make thoughts your aim;  
If you can meet with Triumph and Disaster  
And treat those two impostors just the same;  
If you can bear to hear the truth you've spoken  
Twisted by knaves to make a trap for fools,  
Or watch the things you gave your life to, broken,  
And stoop and build 'em up with worn-out tools.

If you can talk with crowds and keep your virtue,  
Or walk with kings – nor lose the common touch,  
If neither foes nor loving friends can hurt you;  
If all men count with you, but none too much,  
If you can fill the unforgiving minute  
With sixty seconds' worth of distance run,  
Yours is the Earth and everything that's in it,  
And – which is more – you'll be a Man, my son!

*Rudyard Kipling*

I gave him a copy and bid him farewell, hoping that he had found at least something useful to take away from our conversation. I know that I had benefited from the revision lesson. I don't know where you are today my friend, but I hope you've found the answer to your question, firsthand.

She said gently, “Sometimes things don’t turn out the way we plan. Don’t feel hurt.”

“When I don’t feel hurt, I hope they bury me . . . I am the type of person who, if he likes somebody, has to show it.”

– *The Assistant*, Bernard Malamud (1914–1986)

# 11 Approaches to Yield Spread Trading Using Gilts<sup>1</sup>

## 11.1 Introduction

In this chapter we consider yield curve relative value and spread trading using gilts. Portfolio managers who do not wish to put on a naked directional position, but rather believe that the yield curve will change shape and flatten or widen between two selected points, put on relative value trades to reflect their view. Such trades involve simultaneous positions in bonds of different maturity. Other relative value trades may position high-coupon bonds against low-coupon bonds of the same maturity, as a tax-related transaction. These trades are concerned with the change in yield spread between two or more bonds rather than a change in absolute interest rate level. The key factor is that changes in spread are not conditional upon directional change in interest rate levels; that is, yield spreads may narrow or widen whether interest rates themselves are rising or falling.

Typically, spread trades will be constructed as a long position in one bond against a short position in another bond. If it is set up correctly, the trade will only incur a profit or loss if there is change in the shape of the yield curve. This is regarded as being *first-order risk neutral*, which means that there is no interest-rate risk in the event of change in the general level of market interest rates, provided the yield curve experiences essentially a parallel shift. In this chapter we examine some common yield spread trades.

### 11.1.1 *The determinants of yield*

The yield at which a fixed interest security is traded is market-determined. This market determination is a function of three factors: the term-to-maturity of the bond, the liquidity of the bond and its credit quality. Government securities such as gilts are default-free and so this factor drops out of the analysis. Under “normal” circumstances the yield on a bond is higher the

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<sup>1</sup> This chapter is based partly on internal papers written by the author during 1995–1997, when he was working in the gilt market. The prices quoted are tick prices, fractions of 32nds, identical to US Treasury pricing. Gilts are now quoted as decimal prices.

greater its maturity, this reflecting both the expectations hypothesis and liquidity preference theories. Intuitively we associate higher risk with longer-dated instruments, for which investors must be compensated in the form of higher yield. This higher risk reflects greater uncertainty with longer-dated bonds, both in terms of default and future inflation and interest rate levels. However, for a number of reasons the yield curve assumes an inverted shape and long-dated yields become lower than short-dated ones<sup>2</sup>. Long-dated yields, generally, are expected to be less volatile over time compared to short-dated yields. This is mainly because incremental changes to economic circumstances or other technical considerations generally have an impact for only short periods of time, which affects the shorter end of the yield curve to a greater extent.

The liquidity of a bond also influences its yield level. The liquidity may be measured by the size of the bid-offer spread, the ease with which the stock may be transacted in size, and the impact of large-size bargains on the market. It is also measured by the extent of any *specialness* in its repo rate. Supply and demand for an individual stock, and the amount of stock available to trade, are the main drivers of liquidity<sup>3</sup>. The general rule is that there is a yield premium for transacting business in lower-liquidity bonds.

In the analysis that follows we assume satisfactory levels of liquidity, that is, it is straightforward to deal in large sizes without adversely moving the market.

### 11.1.2 *The spread trade*

A relative value trade usually involves a long position set up against a short position in a bond of different maturity. The trade must be weighted so that the two positions are first-order neutral, which means the risk exposure of each position nets out when considered as a single trade, but only with respect to a general change in interest rate levels. If there is a change in yield spread, a profit or loss will be generated.

A common approach to weighting spread trades is to use the *basis point value* (BPV) of each bond<sup>4</sup>. Figure 11.1 shows price and yield data for a set of benchmark gilts for value date 17 June 1997<sup>5</sup>. The BPV for each bond is also shown, per £100 of stock. For the purposes of this discussion we quote mid-prices only and assume that the investor is able to trade at these prices. The yield curve at that date is shown in Figure 11.2.

The yield spread history between these two stocks over the previous three months and up to 16 June 1997's closing yields is shown in Figure 11.3. An investor believes that the yield curve will flatten between the two-year and 10-year sectors of the curve and that the spread between the 6% 1999 and the 7.25% 2007 will narrow further from its present value of 0.299%.

To reflect this view the investor buys the 10-year bond and sells short the two-year bond, in amounts that leave the trade first-order risk neutral. If we assume the investor buys £1 million nominal of the 7.25% 2007 gilt, this represents an exposure of £1230.04 loss (profit) if there is a 1 basis point increase (decrease) in yields. Therefore, the nominal amount of the

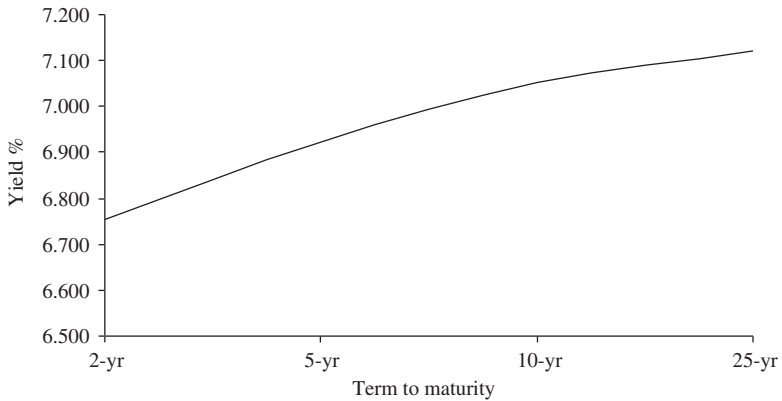
<sup>2</sup> For a summary of term structure theories see Choudhry, M., *The Bond and Money Markets: Strategy, Trading, Analysis*, Chapter 6 (Oxford, UK: Butterworth-Heinemann, 2001).

<sup>3</sup> The amount of stock issued and the amount of stock available to trade are not the same thing. If a large amount of a particular issue has been locked away by institutional investors, this may impede liquidity. However, the existence of a large amount at least means that some of the paper may be made available for lending in the stock loan and repo markets. A small issue size is a good indicator of low liquidity.

<sup>4</sup> This is also known as *dollar value of a basis point* (DVBVP) or *present value of a value point* (PVBVP).

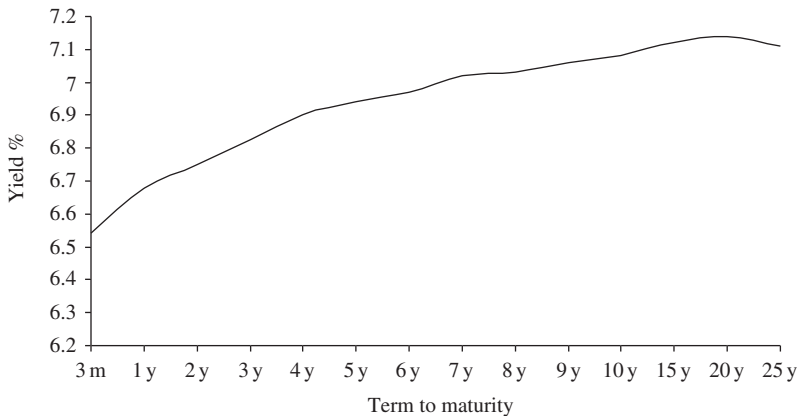
<sup>5</sup> Gilts settle on a T+1 basis.

Term	Bond	Price	Accrued	Dirty price	Yield %	Modified duration	BPV	Per £1m nominal
2-yr	6% 10/8/1999	98-17	127	100.62	6.753	1.689	0.016642	166.42
5-yr	7% 7/6/2002	100-10	10	100.50	6.922	3.999	0.040115	401.15
10-yr	7.25% 7/12/2007	101-14	10	101.64	7.052	6.911	0.070103	701.03
25-yr	8% 7/6/2021	110-01	10	110.25	7.120	11.179	0.123004	1230.04

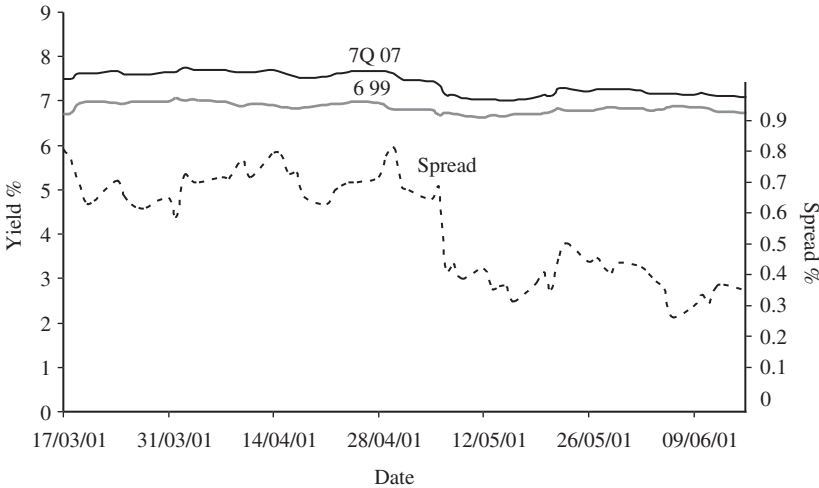


**Figure 11.1:** Gilt prices and yields for value 17 June 1997. (Source: Williams de Broe and Hambros Bank Limited; author’s notes).

short position in the 6% 1999 gilt must equate this risk exposure. The BPV per £1 million nominal of the two-year bond is £166.42, which means that the investor must sell (1230.04/166.42) or £7.3912 million of this bond, given by a simple ratio of the two basis point values. We expect to sell a greater nominal amount of the shorter-dated gilt because its risk



**Figure 11.2:** Benchmark gilt yield curve, 16 June 1997. (Source: Hambros Bank Limited; author’s notes).



**Figure 11.3:** 6% Treasury 1999 and 7¼% 2007 three months’ yield spread history as at 16 June 1997.

**Note:** Yield values are shown on the left axis, spread values on the right, which uses a larger scale for clarity.

exposure is lower. This trade generates cash because the short sale proceeds exceed the long buy purchase funds, which are, respectively

Buy £1m 7.25% 2007	−£1,102,500
Sell £7.39m 6% 1999	+£7,437,025

What are the possible outcomes of this trade? If there is a parallel shift in the yield curve, the trade neither gains nor loses. If the yield spread narrows by, say, 15 basis points, the trade will gain either from a drop in yield on the long side or a gain in yield on the short side, or a combination of both. Conversely, a widening of the spread will result in a loss. Any narrowing spread is positive for the trade, while any widening is harmful.

The trade would be put on the same ratio if the amounts were higher, which is *scaling* the trade. So, for example, if the investor had bought £100 million of the 7.25% 2007, he would need to sell short £739 million of the two-year bonds. However, the risk exposure is greater by the same amount, so that in this case the trade would generate 100 times the risk. As can be imagined, there is a greater potential reward but at the same time a greater amount of stress in managing the position.

Using BPVs to risk-weight a relative value trade is common but suffers from any traditional duration-based measure because of the assumptions used in the analysis. Note that when using this method the ratio of the nominal amount of the bonds must equate the reciprocal of the bonds’ BPV ratio. So in this case the BPV ratio is (166.42/1230.04) or 0.1353, which has a reciprocal of 7.3912. This means that the nominal values of the two bonds must always be in the ratio of 7.39:1. This weighting is not static, however; we know that duration measures are a static (snapshot) estimation of dynamic properties such as yield and term to maturity. Therefore, for anything but very short-term trades the relative

values may need to be adjusted as the BPVs alter over time, so-called *dynamic adjustment* of the portfolio.

Another method to weight trades is by duration-weighting, which involves weighting in terms of market values. This compares to the BPV approach which provides a weighting ratio in terms of nominal values. In practice the duration approach does not produce any more accurate risk weighting.

A key element of any relative value trade is the financing cost of each position. This is where the repo market in each bond becomes important. In the example just described, the financing requirement is: repo out the 7.25% 2007, for which £1.1 million of cash must be borrowed to finance the purchase; the trader pays the repo rate on this stock; and reverse repo the 6% 1999 bond, which must be borrowed in repo to cover the short sale; the trader earns the repo rate on this stock.

If the repo rate on both stocks is close to the general repo rate in the market, there will be a bid-offer spread to pay but the greater amount of funds lent out against the 6% 1999 bond will result in a net financing gain on the trade whatever happens to the yield spread. If the 7.25% 2007 gilt is special, because the stock is in excessive demand in the market (for whatever reason), the financing gain will be greater still. If the 6% 1999 is *special*, the trade will suffer a financing loss.

<HELP> for explanation. N217 Corp RRRR  
 Enter <1><GO> to send screen via <MESSAGE> System.  
**REPO/REVERSE REPO ANALYSIS**

TREASURY		UKT 6 08/10/99		CUSIP: GG7176769	
*BOND IS CUM-DIVIDEND AT SETTLEMENT*					
SETTLEMENT DATE	6/17/97	RATE (365)	6.0000%	COLLATERAL:	100.0000% OF MONEY
PRICE	98.5312500	Y/N, HOLD COLLATERAL PERCENT CONSTANT?		Y/N, BUMP ALL DATES FOR WEEKENDS/HOLIDAYS?	<input checked="" type="checkbox"/>
YIELD	6.7522338	Y/N, BUMP ALL DATES FOR WEEKENDS/HOLIDAYS?			<input checked="" type="checkbox"/>
ACCRUED	2.0876712	ROUNDING	1 = NOT ROUNDED		
FOR 127 DAYS.			2 = ROUND TO NEAREST 1/8		
TOTAL	100.6189212				
*BOND IS CUM-DIVIDEND AT TERMINATION*					
FACE AMT	7391200	SETTLEMENT MONEY	7436945.71		
<OR> To solve for PRICE: Enter NUMBER of BONDS, SETTLEMENT MONEY & COLLATERAL TERMINATION DATE 7/ 1/97 <OR> TERM (IN DAYS) 14 ACCRUED 2.317808 FOR 141 DAYS. Warning: Term extends past coupon date.					

**MONEY AT TERMINATION**

WIRED AMOUNT	7,436,945.71
REPO INTEREST	17,115.16
TERMINATION MONEY	7,454,060.87
NOTES:	

Australia 61 2 9777 8655      Brazil 5511 3048 4500      Europe 44 20 7330 7575      Germany 49 69 92041210  
 Hong Kong 852 2977 6200 Japan 81 3 3201 8880 Singapore 65 212 1234 U.S. 1 212 318 2000      Copyright 2001 Bloomberg L.P.  
 1362-32-0 14-Aug-01 16:08:32



**Figure 11.4:** Bloomberg screen RRRR showing repo cash flows for 6% 1999, 17 June to 1 July 1997. © Bloomberg L.P. Reproduced with permission.



In this case, however, the cash sums involved for each bond make the financing rates academic, as the interest paid in the 7.25% 2007 repo is far outweighed by the interest earned on cash lent out when undertaking reverse repo in the 6% 1999 bond. Therefore, this trade will not be impacted by repo rate bid-offer spreads or specific rates, unless the rate on the borrowed bond is excessively special<sup>6</sup>. The repo financing cash flows for the 6% 1999 and 7.25% 2007 are shown in Figures 11.4 and 11.5 respectively, the Bloomberg repo/reverse repo screen RRRR. They show that at the time of the trade the investor had anticipated a 14-day term for the position before reviewing it and/or unwinding it.

A detailed account of the issues involved in financing a spread trade is contained in Choudhry (2001)<sup>7</sup>.

<HELP> for explanation. N217 Corp RRRR  
 Enter <1><GO> to send screen via <MESSAGE> System.

**REPO/REVERSE REPO ANALYSIS**

TREASURY UKT? 1/4 12/07/07 111.7093/111.7093 (5.06/5.06) BFV @16:09  
 \*BOND IS CUM-DIVIDEND AT SETTLEMENT\* CUSIP: GG7303389

SETTLEMENT DATE	6/17/97	RATE (365)	6.1250%
<SETTLEMENT PRICE>	<MARKET PRICE>	COLLATERAL:	100.0000% OF MONEY
PRICE	101.4375000	Y/N, HOLD COLLATERAL PERCENT CONSTANT?	Y
YIELD	7.0478043	Y/N, BUMP ALL DATES FOR WEEKENDS/HOLIDAYS?	Y
ACCRUED	0.1986301	ROUNDING 1	1 = NOT ROUNDED
FOR 10 DAYS.	0.1986301	2	2 = ROUND TO NEAREST 1/8
TOTAL	101.6361301		

\*BOND IS CUM-DIVIDEND AT TERMINATION\*

FACE AMT	1000000	<OR>	SETTLEMENT MONEY	1016361.30
<OR> To solve for PRICE: Enter NUMBER of BONDS, SETTLEMENT MONEY & COLLATERAL				
TERMINATION DATE	7/ 1/97	<OR>	TERM (IN DAYS)	14
ACCRUED	0.476712	FOR	24 DAYS.	

**MONEY AT TERMINATION**

WIRED AMOUNT	1,016,361.30
REPO INTEREST	2,387.75
TERMINATION MONEY	1,018,749.05

NOTES:

Australia 61 2 9777 8655 Brazil 5511 3048 4500 Europe 44 20 7330 7575 Germany 49 69 92041210  
 Hong Kong 852 2577 6200 Japan 81 3 3201 8880 Singapore 65 212 1234 U.S. 1 212 318 2000 Copyright 2001 Bloomberg L.P.  
 1362-32-0 14-Aug-01 16:10:02



**Figure 11.5:** Bloomberg screen RRRR showing repo cash flows for 7.25% 2007, 17 June to 1 July 1997. © Bloomberg L.P. Reproduced with permission.

<sup>6</sup> In fact the 6% 1999 did experience very special rates at certain times, briefly reaching negative rates at the start of 1998. However, the author had unwound the position long before then!  
<sup>7</sup> Choudhry, M., *The Repo Handbook* (Oxford: UK, Butterworth-Heinemann 2002). And just so you know, this trade was profitable as the yield spread between the 6% 1999 and 7.25% 2007 did indeed narrow, prior to the entire curve inverting just over one month later.

### 11.1.3 Identifying yield spread trades

Yield spread trades are a type of relative value position that a trader can construct when the objective is to gain from a change in the spread between two points on the yield curve. The decision on which sectors of the curve to target is an important one and is based on a number of factors. An investor may naturally target, say, the five- and ten-year areas of the yield curve to meet investment objectives and have a view on these maturities. Or a trader may draw conclusions from studying the historical spread between two sectors.

Yield spreads do not move in parallel, however, and there is not a perfect correlation between the changes of short, medium and long-term sectors of the curve. The money market yield curve can sometimes act independently of the bond curve. Table 11.1 shows the change in benchmark yields during 1996/1997. There is no set pattern in the change in both yield levels and spreads. It is apparent that one segment of the curve can flatten while another is steepening, or remains unchanged.

Another type of trade is where an investor has a view on one part of the curve relative to two other parts of the curve. This can be reflected in a number of ways, one of which is the butterfly trade, which is considered below.

## 11.2 Coupon spreads<sup>8</sup>

Coupon spreads are becoming less common in the gilt market because of the disappearance of high-coupon or other exotic gilts and the concentration on liquid benchmark issues. However, they are genuine spread trades. The US Treasury market presents greater

Changes in yield levels						
	3-month	1-year	2-year	5-year	10-year	25-year
10/11/1996	6.06	6.71	6.83	7.31	7.67	7.91
10/07/1997	6.42	6.96	7.057	7.156	7.025	6.921
Change	0.36	0.25	0.227	-0.154	-0.645	-0.989
10/11/1997	7.15	7.3	7.09	6.8	6.69	6.47
Change	0.73	0.34	0.033	-0.356	-0.335	-0.451
Changes in yield spread						
	3 m/1 y	1 y/2 y	2 y/5 y	5 y/10 y	5 y/25 y	10 y/25 y
10/11/1996	-0.65	-0.12	-0.48	-0.36	-0.6	-0.24
10/07/1997	-0.54	-0.457	-0.099	0.131	0.235	0.104
Change	0.11	-0.337	0.381	0.491	0.835	0.344
10/11/1997	-0.15	0.21	0.29	0.11	0.33	0.22
Change	0.39	0.667	0.389	-0.021	0.095	0.116

**Table 11.1:** Yield levels and yield spreads during November 1996 to November 1997.

(Source: ABN Amro Hoare Govett Sterling Bonds Ltd, Hambros Bank Limited; Tullett & Tokyo; author's notes).

<sup>8</sup> First presented by the author as an internal paper to the head of Treasury at ABN Amro Hoare Govett Sterling Bonds Limited in April 1995. Subsequently incorporated into this chapter.

opportunity for coupon spreads due to the larger number of similar-maturity issues. The basic principle behind the trade is a spread of two bonds that have similar maturity or similar duration but different coupons.

Table 11.2 shows the yields for a set of high-coupon and low(er)-coupon gilts for a specified date in May 1993 and the yields for the same gilts six months later. From the yield curves we see that general yield levels decline by approximately 80–130 basis points. The last column in the table shows that, apart from the earliest pair of gilts (which do not have strictly comparable maturity dates), the performance of the lower-coupon gilt exceeded that of the higher-coupon gilt in every instance. Therefore, buying the spread of the low-coupon versus the high-coupon should, in theory, generate a trading gain in an environment of falling yields. One explanation of this is that the lower-coupon bonds are often the benchmark, which means the demand for them is higher. In addition, during a bull market, more bonds are considered to be “high” coupon as overall yield levels decrease.

The exception noted in Table 11.2 is the outperformance of the 14% Treasury 1996 compared to the lower-coupon 10¼% 1995 stock. This is not necessarily conclusive, because the bonds are six months apart in maturity, which is a significant amount for short-dated stock. However, in an environment of low or falling interest rates, shorter-dated investors such as banks and insurance companies often prefer to hold very high-coupon bonds because of the high income levels they generate. This may explain the demand for the 14% 1996 stock<sup>9</sup> although the evidence at the time was only anecdotal.

Gilt	Maturity	10/05/1993 Yield %	12/11/1993 Yield %	Yield change %
10Q 95	21-Jul-95	6.393	5.390	-1.003
14 96	10-Jan-96	6.608	5.576	-1.032
15Q 96	3-May-96	6.851	5.796	-1.055
13Q 96	15-May-96	6.847	5.769	-1.078
13Q 97	22-Jan-97	7.142	5.999	-1.143
10H 97	21-Feb-97	7.131	5.974	-1.157
7 97	6-Aug-97	7.219	6.037	-1.182
8T 97	1-Sep-97	7.223	6.055	-1.168
15 97	27-Oct-97	7.294	6.113	-1.161
9T 98	19-Jan-98	7.315	6.102	-1.213
7Q 98	30-Mar-98	7.362	6.144	-1.218
6 99	10-Aug-99	7.724	6.536	-1.188
10Q 99	22-Nov-99	7.731	6.552	-1.179
8 03	10-Jun-03	8.075	6.854	-1.221
10 03	8-Sep-03	8.137	6.922	-1.215

**Table 11.2:** Yield changes on high and low-coupon gilts from May 1993 to November 1993. (Source: ABN Amro Hoare Govett Sterling Bonds Ltd; Bloomberg; author’s notes).

<sup>9</sup> This stock also has a special place in the author’s heart, although he was No. 2 on the desk when the Treasury head of desk put on a very large position in it . . . !

## 11.3 Butterfly trades<sup>10</sup>

*Butterfly* trades are another method by which traders can reflect a view on changing yield levels without resorting to a naked punt on interest rates. They are another form of relative value trade; amongst portfolio managers they are viewed as a means of enhancing returns. In essence a butterfly trade is a short position in one bond against a long position of two bonds, one of shorter maturity and the other of longer maturity than the short-sold bond. Duration-weighting is used so that the net position is first-order risk neutral, and nominal values are calculated such that the short sale and long purchase cash flows net to zero, or very closely to zero.

This section reviews some of the aspects of butterfly trades.

### 11.3.1 *Basic concepts*

A butterfly trade is *par excellence* a yield curve trade. If the average return on the combined long position is greater than the return on the short position (which is a cost) during the time the trade is maintained, the strategy will generate a profit. It reflects a view that the short end of the curve will steepen relative to the “middle” of the curve while the long end will flatten. For this reason higher convexity stocks are usually preferred for the long positions, even if this entails a loss in yield. However, the trade is not “risk-free,” for the same reasons that a conventional two-bond yield spread is not. Although, in theory, a butterfly is risk neutral with respect to parallel changes in the yield curve, changes in the shape of the curve can result in losses. For this reason the position must be managed dynamically and monitored for changes in risk relative to changes in the shape of the yield curve.

In a butterfly trade the trader is long a short-dated and long-dated bond, and short a bond of a maturity that falls in between these two maturities. A portfolio manager with a constraint on running short positions may consider this trade as a switch out of a long position in the medium-dated bond and into duration-weighted amounts of the short-dated and long-dated bond. However, it is not strictly correct to view the combined long position to be an exact substitute for the short position – due to liquidity (and other reasons) the two positions will behave differently for given changes in the yield curve. In addition one must be careful to compare like for like, as the yield change in the short position must be analysed against yield changes in *two* bonds. This raises the issue of portfolio yield.

### 11.3.2 *Putting on the trade*

We begin by considering the calculation of the nominal amounts of the long positions, assuming a user-specified starting amount in the short position. In Table 11.3 we show three gilts as at 27 June 1997. The trade we wish to put on is a short position in the five-year bond, the 7% Treasury 2002, against long positions in the two-year bond, the 6% Treasury 1999 and the ten-year bond, the 7.25% Treasury 2007. Assuming £10 million nominal of the

---

<sup>10</sup> Revised and updated version of a paper first presented internally to Adrian Howard (head of Cash-OBS desk, Treasury division) at Hambros Bank Limited in June 1997. Incorporated into this chapter.

	2-year bond	5-year bond	10-year bond
Gilt	6% 1999	7% 2002	7.25% 2007
Maturity date	10 Aug 1999	07 Jun 2002	07 Dec 2007
Price	98-08	99-27	101-06
Accrued interest	2.30137	0.44110	0.45685
Dirty price	100.551	100.285	101.644
GRY %	6.913	7.034	7.085
Duration	1.969	4.243	7.489
Modified duration	1.904	4.099	7.233
Basis point value	0.01914	0.0411	0.07352
Convexity	0.047	0.204	0.676

**Table 11.3:** Bond values for butterfly strategy, June 1997. (Source: author's notes).

five-year bond, the nominal values of the long positions can be calculated using duration, modified duration or basis point values (the last two, unsurprisingly, will generate identical results). The more common approach is to use basis point values.

In a butterfly trade the net cash flow should be as close to zero as possible, and the trade must be basis point value-neutral. Using the following notation,

- $P_1$  the dirty price of the short position;
- $P_2$  the dirty price of the long position in the two-year bond;
- $P_3$  the dirty price of the long position in the ten-year bond;
- $M_1$  the nominal value of the short-position bond, with  $M_2$  and  $M_3$  the long-position bonds;
- $BPV_1$  the basis point value of the short-position bond

if applying basis point values, the amounts required for each stock are given by (11.1)

$$M_1 P_1 = M_2 P_2 + M_3 P_3 \quad (11.1)$$

while the risk-neutral calculation is given by (11.2)

$$M_1 BPV_1 = M_2 BPV_2 + M_3 BPV_3 \quad (11.2)$$

The value of  $M_1$  is not unknown, as we have set it at £10 million. The equations can be rearranged to solve for the remaining two bonds, which are

$$M_2 = \frac{P_1 BPV_3 - P_3 BPV_1}{P_2 BPV_3 - P_3 BPV_2} M_1 \quad (11.3)$$

$$M_3 = \frac{P_2 BPV_1 - P_1 BPV_2}{P_2 BPV_3 - P_3 BPV_2} M_1$$

Using the dirty prices and BPVs from Table 11.3, we obtain the following values for the long positions. The position required is short £10 million 7% 2002 and long £5.347 million of the 6% 1999 and £4.576 million of the 7.25% 2007. With these values the trade results in a zero net cash flow and a first-order risk neutral interest rate exposure. Identical results

would be obtained using the modified duration values, and similar results using the duration measures. If using Macaulay duration the nominal values are calculated using (11.4)

$$D_1 = \frac{MV_2 D_2 + MV_3 D_3}{MV_2 + MV_3} \quad (11.4)$$

where  $D$  and  $MV$  represent duration and market value for each respective stock.

### 11.3.3 Yield gain

We know that the gross redemption yield for a vanilla bond is that rate  $r$  where

$$P_d = \sum_{i=1}^N C_i e^{-rm} \quad (11.5)$$

The right-hand side of equation (11.5) is simply the present value of the cash flow payments  $C$  to be made by the bond in its remaining lifetime. Equation (11.5) gives the continuously compounded yields to maturity; in practice users define a yield with compounding interval  $m$ , that is

$$r = \frac{(e^{rm} - 1)}{m} \quad (11.6)$$

Treasuries and gilts compound on a semi-annual basis.

In principle we may compute the yield on a portfolio of bonds exactly as for a single bond, using equation (11.5) to give the yield for a set of cash flows which are purchased today at their present value. In practice the market calculates portfolio yield as a weighted average of the individual yields on each of the bonds in the portfolio. This is described, for example, in Fabozzi (1993)<sup>11</sup>, and this description points out the weakness of this method. An alternative approach is to weight individual yields using bonds' basis point values, which we illustrate here in the context of the earlier butterfly trade. In this trade we have

- short £10 million 7% 2002;
- long £5.347 million 6% 1999 and £4.576 million 7.25% 2007.

Using the semi-annual adjusted form of equation (11.5) the true yield of the long position is 7.033%. To calculate the portfolio yield of the long position using market value weighting, we may use

$$r_{port} = \left( \frac{MV_2}{MV_{port}} \right) r_2 + \left( \frac{MV_3}{MV_{port}} \right) r_3 \quad (11.7)$$

which results in a portfolio yield for the long position of 6.993%. If we weight the yield with basis point values we use

$$r_{port} = \frac{BPV_2 M_2 r_2 + BPV_3 M_3 r_3}{BPV_2 M_2 + BPV_3 M_3} \quad (11.8)$$

<sup>11</sup> Fabozzi, F., *Bond Portfolio Management*, Chapters 10–14 (FJF Associates, 1996).

Substituting the values from Table 11.3 we obtain

$$r_{port} = \frac{(1,914)(5.347)(6.913) + (7,352)(4.576)(7.085)}{(1,914)(5.347) + (7,352)(4.576)}$$

$$= 7.045\%.$$

We see that using basis point values produces a seemingly more accurate weighted yield, closer to the true yield computed using the expression above. In addition, using this measure a portfolio manager switching into the long butterfly position from a position in the 7% 2002 would pick up a yield gain of 1.2 basis points, compared to the 4 basis points that an analyst would conclude had been lost using the first yield measure<sup>12</sup>.

The butterfly trade therefore produces a yield gain in addition to the capital gain expected if the yield curve changes in the anticipated way.

### 11.3.4 Convexity gain

In addition to yield pick-up, the butterfly trade provides, in theory, a convexity gain which will outperform the short position irrespective of which direction interest rates moved in, provided we have a parallel shift. This is illustrated in Table 11.4. This shows the changes in value of the 7% 2002 as interest rates rise and fall, together with the change in value of the combined portfolio.

Yield change (bps)	7% 2002 value (£)	Portfolio value* (£)	Difference (£)	BPV 7% 2002 (5-year)	BPV 6% 1999 (2-year)	BPV 7.25% 2007 (10-year)
+250	9,062,370	9,057,175	-5,195	0.0363	0.0180	0.0584
+200	9,246,170	9,243,200	-2,970	0.0372	0.0182	0.0611
+150	9,434,560	9,435,200	640	0.0381	0.0184	0.0640
+100	9,627,650	9,629,530	1,880	0.0391	0.0187	0.0670
+50	9,825,600	9,828,540	2,940	0.0401	0.0189	0.0702
0	10,028,500	10,028,500	0	0.0411	0.0191	0.0735
-50	10,236,560	10,251,300	14,740	0.0421	0.0194	0.0770
-100	10,450,000	10,483,800	33,800	0.0432	0.0196	0.0808
-150	10,668,600	10,725,700	57,100	0.0443	0.0199	0.0847
-200	10,893,000	10,977,300	84,300	0.0454	0.0201	0.0888
-250	11,123,000	11,240,435	117,435	0.0466	0.0204	0.0931

\* Combined value of long positions in 6% 1999 and 7.25% 2007. Values rounded. Yield change is parallel shift.

**Table 11.4:** Changes in bond values with changes in yield levels.

<sup>12</sup> The actual income gained on the spread will depend on the funding costs for all three bonds, a function of the specific repo rates available for each bond. Shortly after the time of writing, the 6% Treasury 1999 went special, so the funding gain on a long position in this stock would have been excessive. However, buying the stock outright would have necessitated paying a yield premium, as demand for it increased as a result of it going special. In the event the premium was deemed high, an alternative stock was nominated, the 10.25% Conversion 1999, a bond with near-identical modified duration value.

We observe from Table 11.4 that whatever the change in interest rates, up to a point, the portfolio value will be higher than the value of the short position, although the effect is progressively reduced as yields rise. The butterfly will always gain if yields fall, and protects

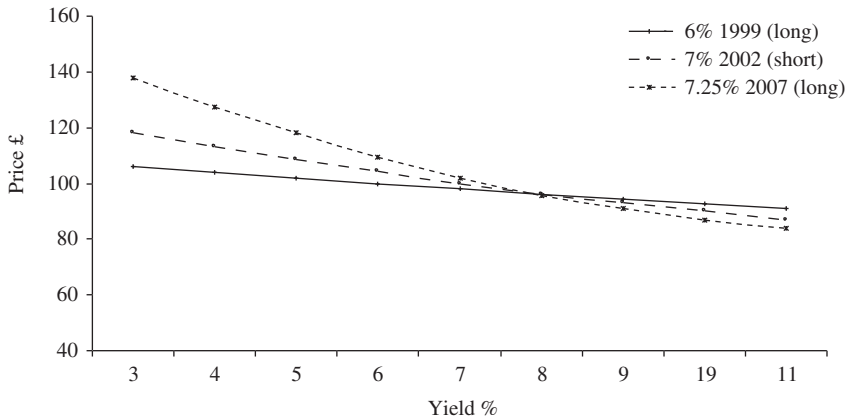


Figure 11.6: Illustration of convexity for each stock in butterfly trade, 27 June 1997.

<HELP> for explanation. DDL24 Corp **BBA**

**BUTTERFLY/BARBELL ARBITRAGE** Page 1 of 6

SETTLE DATE security 1 6/30/97 YIELDS Cnv/Seml/Ann  
 security 2 6/30/97 M=YTM, W=YTW  
 security 3 6/30/97 National (N or C)

BUY/SELL	TKR	SECURITY	CPN	MTY	KEY	PRICE	YIELD	DUR	MOD/ADJ	RISK	Future's PAR (\$1M)	Risk WEIGHT	National (N or C)	DOLLAR PROCEEDS
	UKT	7 02 Govt				99-27	7.032	4.10		4.11	10000	4110	N	10028485
	UKT	6 99 Govt				98-8	6.912	1.90		1.91	10759	2055	N	10818322
	UKT	7.25 07 Govt				101-6	7.081	7.23		7.35	2796	2055	N	2841976

BUTTERFLY SPREAD: -7.1bp GROSS, -3.6bp AVG DIFF 0 3631813

Market Value Weighted Ave Spread (with Cash @6 ): 18.9 BP's

**TOTAL RETURN FOR VARIOUS YIELD SHIFTS**

PARALLEL SHIFT (IN BP's)	UP	100	\$	PIVOTAL SHIFT (IN BP's)		
				NEG.	0	POS.
			\$	1289.02	\$	1289.02
		0	\$	-0.01	\$	-0.01
	DOWN	100	\$	2542.54	\$	2542.54

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 Princeton: 609-279-3000 Singapore: 65-212-1000 Sydney: 2-9775-8686 Tokyo: 3-3201-8900 Sao Paulo: 11-3048-4500  
 1432-212-0 15-Feb-01 13:02:37



Figure 11.7: Butterfly trade analysis on 27 June 1997, on screen BBA. © Bloomberg L.P. Reproduced with permission.



against downside risk if yields rise to a certain extent. This is the effect of convexity; when interest rates rise, the portfolio value declines by less than the short position value, and when rates fall, the portfolio value increases by more. Essentially, the combined long position exhibits greater convexity than the short position. The effect is greater if yields fall, while there is an element of downside protection as yields rise, up to the +150 basis point parallel shift.

Portfolio managers may seek greater convexity whether or not there is a yield pick-up available from a switch. However, the convexity effect is only material for large changes in yield, and so if there was not a corresponding yield gain from the switch, the trade may not perform positively. As we noted, this depends partly on the funding position for each stock. The price/yield profile for each stock is shown in Figure 11.6.

Essentially, by putting on a butterfly as opposed to a two-bond spread or a straight directional play, the trader limits the downside risk if interest rates fall, while preserving the upside gain if yields fall.

### 11.3.5 Analysis using Bloomberg screen “BBA”

To conclude the discussion of butterfly trade strategy, we describe the analysis using the “BBA” screen on Bloomberg. The trade is illustrated in Figure 11.7.

Using this approach, the nominal values of the two long positions are calculated using BPV ratios only. This is shown under the column “Risk Weight,” and we note that the difference is zero. However, the nominal value required for the two-year bond is much

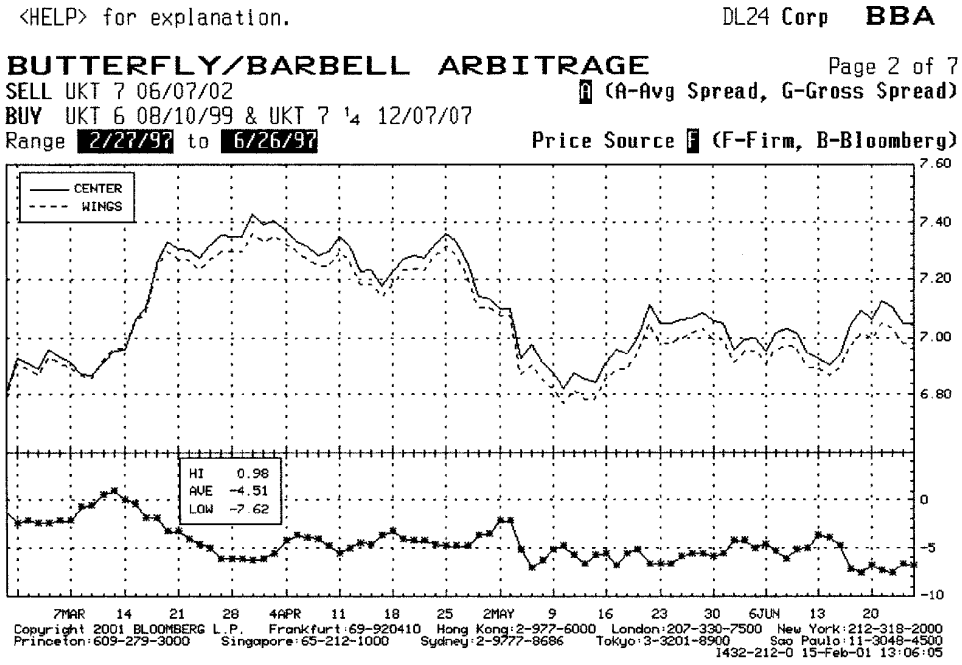


Figure 11.8: Butterfly trade spread history. © Bloomberg L.P. Reproduced with permission.

greater, at £10.76 million, and for the ten-year bond much lower at £2.8 million. This results in a cash outflow of £3.632 million. The profit profile is, in theory, much improved; at the bottom of the screen we observe the results of a 100 basis point parallel shift in either direction, which is a profit. Positive results were also seen for 200 and 300 basis point parallel shifts in either direction. This screen incorporates the effect of a (uniform) funding rate, input on this occasion as 6.00%<sup>13</sup>. Note that the screen allows the user to see the results of a pivotal shift; however, in this example a 0 basis point pivotal shift is selected. This trade therefore created a profit whatever direction interest rates moved in, assuming a parallel shift.

The spread history for the position up to the day before the trade is shown in Figure 11.8, a reproduction of the graph on Bloomberg screen BBA.

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<sup>13</sup> In reality the repo rate will be slightly different for each stock, and there will be a bid-offer spread to pay, but as long as none of the stocks are special the calculations should be reasonably close.

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There are some days in the early spring when the weather is such that, no matter where you are, either in town or countryside, England is at her best and it's good to be alive.

– Geoffrey Wellum, *First Light* (Penguin Books) 2002

# 12 Being Some Reminiscences of the Gilt Market . . .

One day in 1981 a senior Equity Market jobber, and a close friend, decided that it was time I had a career change. I was with Sheppards & Chase and had been since leaving school in 1972. I was quite happy with my role as an institutional dealer with added responsibility for first day dealings in all new share offers. These were challenging occasions as I was not the tallest or strongest of men and life in the crowd that was allowed to gather around your chosen jobber at 09.20 was akin to a rugby scrum. All participants were expected to deal at the first price which was normally the best for clients wishing to sell. At this time one hoped the relationships that had been built with the jobber would pay off.

As the bell sounded at 09.30 the heaving crowd would surge forward in a frenzy to deal. I do not think I was ever later than third to deal on any first day. Having concluded the first deal the immediate problem would be how to get out of the scrum to check the price elsewhere and relay what was going on to the institutional desk via the radio that one hoped would stay alive. On one occasion, having dealt successfully, I remember being hauled from the “scrum” sideways by a colleague with my feet completely off the ground. As he pulled me free we both fell to the floor and, regaining my composure, quickly ran to check the market elsewhere. This was not something that would ever happen in the gilt market!

It was during my time at Sheppards that this first gilt market event took place. The gilt and equity dealers shared the same box at that time so we were on hand to witness one of the most audacious events on the floor of the Stock Exchange in the gilt market. Sheppards were also money brokers and for reasons of security their offices were out of bounds to the rest of the company. Within this area was an exuberant young clerk who, for the purposes of this piece, we will call Jones. Jones was a quick witted and talented live-wire who had appeared on the TV talent show of the time called “Opportunity Knocks” hosted by Hughie Green. History does not relate how Jones fared but it is enough to say that he appeared on the programme as a comedian.

The money room was frequently visited by gilt partners after the market had closed to see how the firm was positioned. Jones would stand ready on a chair behind the door when the senior gilt partner was due at 15.45. As the door went back Jones would launch himself forwards and cling to the back of the tall Old Etonian partner like a new born monkey. As this had become a regular occurrence the partner would calmly request that Jones get off and return to work. As Jones had been with the company some years it was not an

unreasonable request when he asked to spend some time on the floor of the market as a Blue Button with the gilt dealers.

This was arranged and, on the appointed Monday, Jones appeared for his duties dressed in a two-tone tonic mohair suit. This was the height of fashion for the time: outside business hours in the City that is. It was decided that for his two day stay, Jones was not to be allowed on to the market floor!

On the second day, around lunchtime, an important short-dated gilt client rang to ask what the market was doing. Only Jones and the dealer who answered the call were in the box. As the dealer could not leave the telephones unattended he barked a request at Jones to go into the market and ascertain its movement.

Jones set off for the market in response to this order.

As he entered the market his appearance was noted and the market hushed. He looked around and headed for the lone figure of a jobber the same height as himself but a little more rotund. He was approaching the most senior gilt partner of a most senior firm who had come to the market on one of his infrequent visits to see how it still worked.

Jones approached him and eventually they stood nose to nose, eye to eye. As the market waited there was silence. Suddenly Jones broke the ice and asked the question he had been sent for and, poking the jobber playfully in the ribs asked.

“Hello Tubs, what’s this market doing then?”

The market froze; what would happen next?

Looking around and seeing the apparent interest, the senior jobber patted Jones on the head, smiled, and said,

“The market is an eighth better on the opening.”

Jones responded to this answer in his usual manner,

“Thanks mate”

With this he walked calmly out of the market to report his findings. The market breathed a sigh of relief that all had ended well.

After nine years in equities my jobber friend, Bryan Cavill, suggested a move to the gilt market. He had heard that there was an opportunity and I should apply. It was time to move firms but, as reluctant as I was, there comes a time when moving is the only way to progress and be taken seriously. The firm in question was Carr Sebag who were not having the best of times, but if I could establish myself in the gilt market anything could happen.

I managed to obtain the position as gilt dealer and started around July 1981. The most important part of this move was that whilst Carr Sebag did not transact the largest business, I would get the opportunity to work with two of the most genuine and well respected men in the market. These were D.J. Dawe and John Simmonds. They were the ideal men to work alongside as an introduction to the gilt market. This market had its characters. The gilt market, especially on the jobbing side, was awash with them.

It seems unreal now to look back on a market that opened at 10.00am. There was little contact before hours, unlike the equity market where lists of early indications were gathered from 8.30am onwards. I always thought this a pointless activity as these early indications rarely equated to the first prices made on the Bell at 9.30am as jobbers did not want to give away how they were really going to open the market! Whilst the equity brokers scurried

earnestly between pitches in the opening frenzy, those assembling for the gilt day were still discussing the forthcoming economic figures, whether the tap stock was about to be exhausted or last evening's televisual highlights.

I dealt in the long end, this being a different world from the short-dated market. The two had different practices and culture. The short end was full of price terminology such as three eighths clo clo and either side of an eighth. The long end dealt in sensible fractions with spreads such as a quarter five-eighths or a half seven-eighths. The partner in charge of the short end at Sebag was a strong-willed man who constantly disagreed with the way his dealing instructions were carried out. There was often much heated discussion as to the performance of the three young short dealers who worked for him during my stay.

One morning his current dealer rang to say he was unwell and would not be coming in. It looked as though it could be a turbulent opening making for a tense atmosphere in the box. The three of us long end chaps were watching events unfold with a certain amount of amusement. I suddenly had the smile wiped from my face when a radio and short list were thrust into my chest and I was told to go in and take down the opening prices! Given my comments earlier about short price terminology I had no chance of obtaining this list of prices at the first go, even if the jobber concerned was to dictate it to me personally.

I joined the waiting group around my chosen pitch, fully committed to making the best of the moment. I knew I could not do well; it was a matter of not failing completely. As was the practice in those days the jobbers made a theatrical entrance at 9.59am pushing their way through the assembled brokers whence they turned and began their performance. With pencil poised at the top of my list the jobber I had chosen proudly announced that today he was starting from the bottom upwards. After the third price had been rattled off I was lost. At the end of the list I had taken down the first and last price. This is where the camaraderie of the gilt market came in. I attached myself to a friend who was a seasoned short dealer and he allowed me to listen in as he radioed the list, from the top, to his box. Although several minutes behind I then transmitted my list to the waiting partner and all was well. That sort of help was always given willingly in those days.

At the long end a group of dealers would gather after the close of the market to agree a list of prices that would be published the next day as the "Consortium". This group comprised dealers from the same five or six broking firms every day. This was meant to be a general agreement of where the market had finished as a snapshot of the end of the day. As the different stocks were called, each would give his opinion of where they had closed. As stated before these were normally three-eighths or half point prices in those days but there was always one dealer who said he knew where he could get a sixteenth improvement on every price. When actually dealing we might all have managed to find this improvement but for the purposes of our list it was totally irrelevant. I later worked with this man when he became a gilt market maker; he will know who he is if he reads this!

One leading jobbing firm had their fair share of eccentrics at the long end. One in particular had a fascination for the fact that I had very thick glasses owing to extreme myopia. My optician had added a tint to lessen the noticeable nature of their thickness. Under the strong lights of the Stock Exchange floor my lenses took on the appearance of Joseph's Technicolour Dreamcoat and this fascinated the senior jobber in question. Dealers would only approach this gentleman to ask a price if there were no others to ask. I would

walk on to the pitch and wait to be served. After a while he would notice that a broker was on his pitch and, swinging round, breaking from his reverie, would raise himself to his full height and say,

“Yes?”

One was suddenly transported back to Dickensian times when *Oliver Twist* had the audacity to ask for more. Seeing it was me he would bend forward to examine the colours refracted by my spectacles that seemingly always attracted his attention. As I asked my price he would peer closely into my lenses at a distance usually reserved for my optician holding an instrument shining a light. Just as suddenly he would deliver the price, recoil, spin round and continue his silent deliberations.

In the middle eighties Carr Sebag closed its doors and Grieveson Grant stepped in to take parts of the business. After some deliberation I was engaged by Grieveson to be the fixed interest dealer for the team acquired from Sebag. We would work from the Grieveson gilt box and, with their reputation, I was somewhat nervous at the prospect.

I was made to feel welcome and settled in well. It was now that I really saw business in the gilt market. Although a fixed interest dealer, I stood in at the long end when required. I had never seen orders of such magnitude, and it was treated as the norm. I continued this way until “Big Bang” came along and markets changed forever.

This change came earlier for the fixed market and with Grieveson having been bought by Kleinwort Benson I found myself making markets in the stocks I used to deal in on the floor of the market from a desk in Kleinwort’s office. It was a strange feeling to have become a “jobber”, pitting oneself against the experienced jobbers who had a career’s worth of experience behind them.

Moorad has a favourite story of mine, showing the ways in which young dealers were taught stock market etiquette by jobbers in a jocular fashion whilst still teaching them a lesson to remember. Under market rules a broker, having been made a price, could ask if there was a “way”. If the jobber agreed, even if it did not suit, the broker was obliged to deal. An astute broker would soon learn to request if there was a way “on the basis” with the “basis” being a closing up of the original price made. Young dealers, keen to impress, and being aware of the need to say “on the basis”, would ask if there was a way. The wily jobber, spotting a new boy, would agree on one condition. He would write down his “way” if the broker would do the same. If the original price had been a quarter, five-eighths then the improvement would either be three-eighths five-eighths or a quarter a-half. Either way the broker had to deal having been made the close price.

Both broker and jobber scribbled their respective ways on their note pads. The jobber would then request that the young broker show his hand as to whether he was a buyer or seller. As soon as the broker showed his note, stating that he was a buyer, the jobber would instantly reveal his note that read “same”. The jobber could not lose. He had effectively made three-eighths five-eighths, closing his spread, whilst the broker was committed to pay the original price of five-eighths. Had the broker written seller, then the effective price would have been a quarter to a half. The jobber would have been the winner again.

The gilt market was a fabulous place to be at the time I am relating. Some very serious business was transacted quietly and without causing the wild moves in the market that became a regular occurrence after Big Bang was fully established. Tell a gilt jobber in the 1970s that the long end would move three or four points up and down in one day and he

would have said you had been in the Jamaica<sup>1</sup> too long! From 1987 young traders such as “Harry” Cross were to take up the challenge of the new gilt market, with two tick prices at the long end, instead of the old three-eighths or even half a point if times were difficult.

As a young dealer at Sheppards I will always remember the words of Julian Seymour, the Senior Equity Dealing Partner, who had had a background in the gilt market.

“James, always remember, this is a great game played slowly.”

Oh for those days...

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<sup>1</sup> For those unfamiliar with the City, this is a popular hostelry on St Michael’s Alley, just off Cornhill. Dating from circa 1652, this was one of the first coffee houses in the City frequented by gentlemen.



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Life moves pretty fast. If you don't stop to look around,  
you could miss it.

– Matthew Broderick  
*Ferris Bueller's Day Off* 1987

# Glossary

## A

**Accrued interest:** The proportion of interest or coupon earned on an investment from the previous coupon payment date until the value date.

**Accrued benefit obligation:** Present value of pension benefits that have been earned by an employee to date, whether vested in the employee or not. It can be an important measure when managing the asset/liability ratio of pension funds.

**Accumulated value:** The same as **Future value**.

**ACT/360:** A day/year count convention taking the number of calendar days in a period and a “year” of 360 days.

**ACT/365:** A day/year convention taking the number of calendar days in a period and a “year” of 365 days. Under the ISDA definitions used for interest rate swap documentation, ACT/365 means the same as **ACT/ACT**.

**ACT/ACT:** A day/year count convention taking the number of calendar days in a period and a year equal to the number of days in the current coupon period, multiplied by the coupon frequency. For an interest rate swap, that part of the interest period falling in a leap year is divided by 366 and the remainder is divided by 365.

**Add on factor:** Simplified estimate of the potential future increase in the replacement cost, or market value, of a derivative transaction.

**All-in price:** See “dirty price”.

**Amortising:** An amortising principal is one which decreases during the life of a deal, or is repaid in stages during a loan. Amortising an amount over a period of time also means accruing for it pro rata over the period. See **Bullet**.

**Annuity:** An investment providing a series of (generally equal) future cash flows.

**Appreciation:** An increase in the market value of a currency in terms of other currencies.

**Arbitrage:** The process of buying securities in one country, currency or market, and selling identical securities in another to take advantage of price differences. When this is carried out simultaneously, it is in theory a risk-free transaction. There are many forms of arbitrage transactions. For instance in the cash market a bank might issue a money market instrument in one money centre and invest the same amount in another centre at a higher rate, such as an issue of three-month US dollar CDs in the United States at 5.5% and a purchase of three-month Eurodollar CDs at 5.6%. In the futures market arbitrage might involve buying three-month contracts and selling forward six-month contracts.

**Arbitrageur:** Someone who undertakes arbitrage trading.

**Ask:** See **Offer**.

**Asset:** Probable future economic benefit obtained or controlled as a result of past events or transactions. Generally classified as either current or long-term.

**Asset & Liability Management (ALM):** The practice of matching the term structure and cash flows of an organisation's asset and liability portfolios to maximise returns and minimise risk.

**Asset allocation:** Distribution of investment funds within an asset class or across a range of asset classes for the purpose of diversifying risk or adding value to a portfolio.

**Asset securitisation:** The process whereby loans, receivables and other illiquid assets in the balance sheet are packaged into interest-bearing securities that offer attractive investment opportunities.

**Asset-backed security:** A security which is collateralised by specific assets, such as mortgages, rather than by the intangible creditworthiness of the issuer.

**Asset swap:** An interest rate swap or currency swap used in conjunction with an underlying asset such as a bond investment. See **Liability swap**.

**At-the-money (ATM):** An option is at-the-money if the current value of the underlying is the same as the strike price.

**Auction:** A method of issue where institutions submit bids to the issuer on a price or yield basis. Auction rules vary considerably across markets.

## B

**Backwardation:** The situation when a forward or futures price for something is lower than the spot price (the same as forward discount in foreign exchange).

**Balance sheet:** Statement of the financial position of an enterprise at a specific point in time, giving assets, liabilities and stockholders' equity.

**Banker's acceptance:** See **Bill of exchange**.

**Base currency:** Exchange rates are quoted in terms of the number of units of one currency (the variable or counter currency) which corresponds to one unit of the other currency (the base currency).

**Basis:** The underlying cash market price minus the futures price. In the case of a bond futures contract, the futures price must be multiplied by the conversion factor for the cash bond in question.

**Basis points:** In interest rate quotations, 0.01 per cent.

**Basis risk:** A form of market risk that arises whenever one kind of risk exposure is hedged with an instrument that behaves in a similar, but not necessarily identical way. For instance a bank trading desk may use three-month interest rate futures to hedge its commercial paper or euronote programme. Although eurocurrency rates, to which futures prices respond, are well correlated with commercial paper rates, they do not always move in lock step. If therefore commercial paper rates move by ten basis points but futures prices dropped by only seven basis points, the three basis point gap would be the basis risk.

**Basis swap:** An interest rate swap where both legs are based on floating rate payments.

**Basis trade:** Buying the basis means selling a futures contract and buying the commodity or instrument underlying the futures contract. Selling the basis is the opposite.

**Bearer bond:** A bond for which physical possession of the certificate is proof of ownership. The issuer does not know the identity of the bondholder. Traditionally the bond carries detachable coupon, one for each interest payment date, which are posted to the issuer when payment is due. At maturity the bond is redeemed by sending in the certificate for repayment. These days bearer bonds are usually

settled electronically, and while no register of ownership is kept by the issuer, coupon payments may be made electronically.

**Bear spread:** A spread position taken with the expectation of a fall in value in the underlying.

**Benchmark:** A bond whose terms set a standard for the market. The benchmark usually has the greatest liquidity, the highest turnover and is usually the most frequently quoted. It also usually trades expensive to the yield curve, due to higher demand for it amongst institutional investors.

**Beta:** The sensitivity of a stock relative to swings in the overall market. The market has a beta of one, so a stock or portfolio with a beta greater than one will rise or fall more than the overall market, whereas a beta of less than one means that the stock is less volatile.

**Bid:** The price at which a market maker will buy bonds. A tight bid–offer spread is indicative of a liquid and competitive market. The bid rate in a **Repo** is the interest rate at which the dealer will borrow the **Collateral** and lend the cash. See **Offer**.

**Bid figure:** In a foreign exchange quotation, the exchange rate omitting the last two decimal places. For example, when EUR/USD is 1.1910/20, the big figure is 1.19. See **Points**.

**Bid–Offer:** The two-way price at which a market will buy and sell stock.

**Bill:** A *bill of exchange* is a payment order written by one person (the drawer) to another, directing the latter (drawee) to pay a certain amount of money at a future date to a third party. A bill of exchange is a bank draft when drawn on a bank. By accepting the draft, a bank agrees to pay the face value of the obligation if the drawer fails to pay, hence the term *banker's acceptance*. A *Treasury bill* is short-term government paper of up to one year's maturity, sold at a discount to principal value and redeemed at par.

**Bill of exchange:** A short-term, **Zero-coupon** debt issued by a company to finance commercial trading. If it is guaranteed by a bank, it becomes a banker's acceptance.

**Black-Scholes:** A widely used option pricing formula devised by Fischer Black and Myron Scholes.

**Bloomberg:** The trading, analytics and news service produced by Bloomberg L.P., also used to refer to the terminal itself.

**Bond basis:** An interest rate is quoted on a bond basis if it is on an **ACT/365**, **ACT/ACT** or **30/360** basis. In the short term (for accrued interest, for example), these three are different. Over a whole (non-leap) year, however they all equate to 1. In general, the expression “bond basis” does not distinguish between them and is calculated as ACT/365. See **Money-market basis**.

**Bond-equivalent yield:** The yield which would be quoted on a US treasury bond which is trading at par and which has the same economic return and maturity as a given treasury bill.

**Bootstrapping:** Building up successive zero-coupon yields from a combination of coupon-bearing yields.

**Bpv:** Basis point value. The price movement due to a one basis point change in yield.

**Broker-dealers:** Members of the London Stock Exchange who may intermediate between customers and market makers; may also act as principals, transacting business with customers from their own holdings of stock.

**Bulldog:** Sterling domestic bonds issued by non-UK domiciled borrowers. These bonds trade under a similar arrangement to gilts and are settled via the Central Gilts Office (now CREST).

**Bullet:** A loan/deposit has a bullet maturity if the principal is all repaid at maturity. See **Amortising**.

**Buy/sell-back:** Opposite of **Sell/buy-back**.

## C

**Cable:** The exchange rate for sterling against the US dollar.

**CAD:** The European Union's Capital Adequacy Directive.

**Callable bond:** A bond which provides the borrower with an option to redeem the issue before the original maturity date. In most cases certain terms are set before the issue, such as the date after which the bond is callable and the price at which the issuer may redeem the bond.

**Call option:** An option to purchase the commodity or instrument underlying the option. See **Put**.

**Call price:** The price at which the issuer can call in a bond or preferred bond.

**Capital market:** Long-term market (generally longer than one year) for financial instruments. See **Money market**.

**CBOT:** The Chicago Board of Trade, one of the two futures exchanges in Chicago, USA and one of the largest in the world.

**CD:** See **Certificate of deposit**.

**Central Gilt Office:** The office of the Bank of England which runs the computer-based settlement system for gilt-edged securities and certain other securities (mostly bulldogs) for which the Bank acts as Registrar.

**Certificate of Deposit (CD):** A money market instrument of up to one year's maturity (although CDs of up to five years have been issued) that pays a bullet interest payment on maturity. After issue, CDs can trade freely in the secondary market, the ease of which is a function of the credit quality of the issuer.

**CGBR:** Central Government Borrowing Requirement.

**CGNCR:** Central Government Net Cash Requirement.

**CGO reference prices:** Daily prices of gilt-edged and other securities held in CGO which are used by CGO in various processes, including revaluing stock loan transactions, calculating total consideration in a repo transaction, and **DBV** assembly.

**Cheapest to deliver:** (Or **CTD**). In a bond futures contract, the one underlying bond among all those that are deliverable, which is the most price-efficient for the seller to deliver.

**Classic repo:** Repo is short for "sale and repurchase agreement" – a simultaneous spot sale and forward purchase of a security, equivalent to borrowing money against a loan of collateral. A reverse repo is the opposite. The terminology is usually applied from the perspective of the repo dealer. For example, when a central bank does repos, it is lending cash (the repo dealer is borrowing cash from the central bank).

**Clean deposit:** The same as **Time deposit**.

**Clean price:** The price of a bond excluding accrued coupon. The price quoted in the market for a bond is generally a clean price rather than a **Dirty price**.

**Close-out netting:** The ability to net a portfolio of contracts with a given counterparty in the event of default.

**CMO:** Central Moneymarkets Office which settles transactions in Treasury bills and other money market instruments, and provides a depository.

**CMTM:** Current **mark-to-market** value.

**Collateral:** Something of value, often of good creditworthiness such as a government bond, given temporarily to a counterparty to enhance a party's creditworthiness. In a **repo**, the collateral is actually sold temporarily by one party to the other rather than merely lodged with it.

**Commercial paper:** A short-term security issued by a company or bank, generally with a zero coupon.

**Competitive bid:** A bid for the stock at a price stated by a bidder in an auction. Non-competitive bid is a bid where no price is specified; such bids are allotted at the weighted average price of successful competitive bid prices.

**Compound interest:** When some interest on an investment is paid before maturity and the investor can reinvest it to earn interest on interest, the interest is said to be compounded. Compounding generally assumes that the reinvestment rate is the same as the original rate. See **Simple interest**.

**Consideration:** The total price paid in a transaction, including taxes, commissions and (for bonds) accrued interest.

**Continuous compounding:** A mathematical, rather than practical, concept of compound interest where the period of compounding is infinitesimally small.

**Contract date:** The date on which a transaction is negotiated. See **Value date**.

**Contract for differences:**

**Conventional gilts (including double-dated):** Gilts on which interest payments and principal repayments are fixed.

**Conversion factor:** In a bond futures contract, a factor to make each deliverable bond comparable with the contract's notional bond specification. Define as the price of one unit of the deliverable bond required to make its yield equal to the notional coupon. The price paid for a bond on delivery is the futures settlement price times the conversion factor.

**Convertible currency:** A currency that may be freely exchanged for other currencies.

**Convexity:** A measure of the curvature of a bond's price/yield curve

(mathematically,  $\frac{d^2P}{dr^2}$  / dirty price).

**Cost of carry:** The net running cost of holding a position (which may be negative), for example, the cost of borrowing cash to buy a bond less the coupon earned on the bond while holding it.

**Coupon:** The interest payment(s) made by the issuer of security to the holders, based on the coupon rate and the face value.

**Cover:** To cover an exposure is to deal in such a way as to remove the risk – either reversing the position, or hedging it by dealing in an instrument with a similar but opposite risk profile. Also the amount by how much a bond auction is subscribed.

**CP:** See **Commercial paper**.

**Credit (or default) risk:** The risk that a loss will be incurred if a counterparty to a derivatives transaction does not fulfil its financial obligations in a timely manner.

**Credit derivatives:** Financial contracts that involve a potential exchange of payments in which at least one of the cash flows is linked to the performance of a specified underlying credit-sensitive asset or liability.

**Credit spread:** The interest rate spread between two debt issues of similar duration and maturity, reflecting the relative creditworthiness of the issuers.

**Credit swaps:** Agreement between two counterparties to exchange disparate cash flows, at least one of which must be tied to the performance of a credit-sensitive asset or to a portfolio or index of such assets. The other cash flow is usually tied to a **Floating rate** index (such as **LIBOR**) or a fixed rate or is linked to another credit-sensitive asset.

**CREST:** The paperless share settlement system through which trades conducted on the London Stock Exchange can be settled. The system is operated by CRESTCo and was introduced in 1996.

**CRND:** Commissioners for the Reduction of the National Debt, formally responsible for investment of funds held within the public sector, e.g. National Insurance Fund.

**Cross:** See **Cross-rate**.

**Cross-rate:** Generally an exchange rate between two currencies, neither of which is the US dollar. In the American market, spot cross is the exchange rate for US dollars against Canadian dollars in its direct form.

**CTD:** See **Cheapest to deliver**.

**Cum dividend:** Literally “with dividend”, stock that is traded with interest or dividend accrued included in the price.

**Current yield:** Bond coupon as a proportion of clean price per 100; does not take principal gain/loss or time value of money into account. See **Yield to maturity**, **Simple yield to maturity**.

## D

**Day count:** The convention used to calculate accrued interest on bonds and interest on cash. For UK gilts the convention changed to **actual/actual** from **actual/365** on 1 November 1998. For cash the convention in sterling markets is **actual/365**.

**DBV (delivery by value):** A mechanism whereby a CGO member may borrow from or lend money to another CGO member against overnight gilt collateral. The CGO system automatically selects and delivers securities to a specified aggregate value on the basis of the previous night’s CGO reference prices; equivalent securities are returned the following day. The DBV functionality allows the giver and taker of collateral to specify the classes of security to include within the DBV. The options are: all classes of security held within CGO, including strips and bulldogs; coupon bearing gilts and bulldogs; coupon bearing gilts and strips; only coupon bearing gilts.

**Debenture:** In the US market, an unsecured domestic bond, backed by the general credit quality of the issuer. Debentures are issued under a trust deed or indenture. In the UK market, a bond that is secured against the general assets of the issuer.

**Debt Management Office (DMO):** An executive arm of the UK Treasury, responsible for cash management of the government’s borrowing requirement. This includes responsibility for issuing government bonds (gilts), a function previously carried out by the Bank of England. The DMO began operations in April 1998.

**Deliverable bond:** One of the bonds which is eligible to be delivered by the seller of a bond futures contract at the contract’s maturity, according to the specifications of that particular contract.

**Delivery:** Transfer of gilts (in settlements) from seller to buyer.

**Delivery versus payment (DVP):** The simultaneous exchange of securities and cash. The assured payment mechanism of the CGO achieves the same protection.

**Derivative:** Strictly, any financial instrument whose value is derived from another, such as a forward foreign exchange rate, a futures contract, an option, an interest rate swap, etc. Forward deals to be settled in full are not always called derivatives, however.

**Devaluation:** An official one-off decrease in the value of a currency in terms of other currencies.

**Dirty price:** The price of a bond including accrued interest. Also known as the “all-in” price.

**Discount:** The amount by which a currency is cheaper, in terms of another currency, for future delivery than for spot, is the forward discount (in general, a reflection of interest rate differentials between two currencies). If an exchange rate is “at a discount” (without specifying to which of the two currencies this refers), this generally means that the **Variable currency** is at a discount. See **Premium**.

**Discount house:** In the UK money market, originally securities houses that dealt directly with the Bank of England in T-bills and bank bills, or discount instruments, hence the name. Most discount houses were taken over by banking groups and the term is not generally used, as the BoE now also deals directly with clearing banks and securities houses.

**Discount rate:** The method of market quotation for certain securities (US and UK treasury bills, for example), expressing the return on the security as a proportion of the face value of the security received at maturity – as opposed to a **Yield** which expresses the yield as a proportion of the original investment.

**DMO:** The UK Debt Management Office.

**DMR:** The Debt Management Report, published annually by HM Treasury.

**DRM:** Debt and Reserves Management Team in HM Treasury.

**Duration:** A measure of the weighted average life of a bond or other series of cash flows, using the present values of the cash flows as the weights. See **Modified duration**.

**Duration gap:** Measurement of the interest rate exposure of an institution.

**Duration weighting:** The process of using the modified duration value for bonds to calculate the exact nominal holdings in a spread position. This is necessary because £1 million nominal of a two-year bond is not equivalent to £1 million of say, a five-year bond. The modified duration value of the five-year bond will be higher, indicating that its “basis point value” (bpv) will be greater, and that therefore £1 million worth of this bond represents greater sensitivity to a move in interest rates (risk). As another example consider a fund manager holding £10 million of five-year bonds. The fund manager wishes to switch into a holding of two-year bonds with the same overall risk position. The basis point values of the bonds are 0.041583 and 0.022898 respectively. The ratio of the bpvs is  $0.041583/0.022898 = 1.816$ . The fund manager therefore needs to switch into  $£10m \times 1.816 = £18.160$  million of the two-year bond.

**DVP:** Delivery versus payment, in which the settlement mechanics of a sale or loan of securities against cash is such that the securities and cash are exchanged against each other simultaneously through the same clearing mechanism and neither can be transferred unless the other is.

## E

**Early exercise:** The exercise or assignment of an option prior to expiration.

**ECU:** The European Currency Unit, a basket composed of European Union currencies, now defunct following the introduction of euro currency.

**Effective rate:** An effective interest rate is the rate which, earned as simple interest over one year, gives the same return as interest paid more frequently than once per year and then compounded. See **Nominal rate**.

**Embedded option:** Interest rate-sensitive option in debt instrument that affects its redemption. Such instruments include **Mortgage-backed securities** and **Callable bonds**.

**Equity:** The residual interest in the net assets of an entity that remains after deducting the liabilities.

**Equity options:** Options on shares of an individual common stock.

**Equity warrant:** Warranty, usually attached to a bond, entitling the holder to purchase share(s).

**Euribor:** The reference rate for the euro currency, set in Frankfurt.

**Euro:** The name for the domestic currency of the European Monetary Union. Not to be confused with **Eurocurrency**.

**Euroclear:** An international clearing system for Eurocurrency and international securities. Euroclear is based in Brussels and managed by Morgan Guaranty Trust Company.

**Eurocurrency:** A Eurocurrency is a currency owned by a non-resident of the country in which the currency is legal tender. Not to be confused with **Euro**.

**Euro-issuance:** The issue of gilts (or other securities) denominated in euros.



**Euromarket:** The international market in which **Eurocurrencies** traded.

**European:** A European **Option** is one that may be exercised only at **Expiry**.

**Exchange controls:** Regulations restricting the free convertibility of a currency into other currencies.

**Exchange rate agreement:** A contract for differences based on the movement in a forward-forward foreign exchange swap price. Does not take account of the effect of **Spot** rate changes as an FXA does. See **SAFE**.

**Exchange-traded: Futures** contracts are traded on a futures exchange, as opposed to forward deals which are **OTC**. **Option** contracts are similarly exchange traded rather than **OTC**.

**Ex-dividend (xd) date:** A bond's record date for the payment of coupons. The coupon payment will be made to the person who is the registered holder of the stock on the xd date. For UK gilts this is seven working days before the coupon date.

**Exercise:** To exercise an **Option** (by the holder) is to require the other party (the **Writer**) to fulfil the underlying transaction. Exercise price is the same as **Strike** price.

**Expected (credit) loss:** Estimate of the amount a derivatives counterparty is likely to lose as a result of default from a derivatives contract, with a given level of probability. The expected loss of any derivative position can be derived by combining the distributions of credit exposures, rate of recovery and probabilities of default.

**Expected rate of recovery:** See **Rate of recovery**.

**Expiry:** An option's expiry is the time after which it can no longer be **Exercised**.

**Exposure:** Risk to market movements.

**Exposure profile:** The path of worst-case or expected exposures over time. Different instruments reveal quite differently-shaped exposures profiles due to the interaction of the diffusion and amortisation effects.

**Extrapolation:** The process of estimating a price or rate for a particular value date, from other known prices, when the value date required lies outside the period covered by the known prices.

## F

**Face value:** The principal amount of a security generally repaid ("redeemed") all at maturity, but sometimes repaid in stages, on which the **Coupon** amounts are calculated.

**Fixing:** See **Libor fixing**.

**Floating rate:** An interest rate set with reference to an external index. Also an instrument paying a floating rate is one where the rate of interest is refixed in line with market conditions at regular intervals such as every three or six months. In the current market, an exchange rate determined by market forces with no government intervention.

**Floating rate CD:** CD on which the rate of interest payable is refixed in line with market conditions at regular intervals (usually six months).

**Floating rate gilt:** Gilt issued with an interest rate adjusted periodically in line with market interbank rates.

**Floating rate note: Capital market** instrument on which the rate of interest payable is refixed in line with market conditions at regular intervals (usually six months).

**Forward rate agreement (FRA):** Short-term interest rate hedge. Specifically, a contract between buyer and seller for an agreed interest rate on a notional deposit of a specified maturity on a predetermined future date. No principal is exchanged. At maturity the seller pays the buyer the difference if rates have risen above the agreed level, and vice versa.

**FRN:** See **Floating rate note**.

**FSA:** The Financial Services Authority, the body responsible for the regulation of investment business, and the supervision of banks and money market institutions in the UK. The FSA took over these duties from nine “self-regulatory organisations” that had previously carried out this function, including the Securities and Futures Authority (SFA), which had been responsible for regulation of professional investment business in the City of London. The FSA commenced its duties in 1998.

**FTSE-100:** Index comprising 100 major UK shares listed on The International Stock Exchange in London. Futures and options on the index are traded at the London International Financial Futures and Options Exchange (**LIFFE**).

**Fungible:** A financial instrument that is equivalent in value to another, and easily exchanged or substituted. The best example is cash money, as a £10 note has the same value and is directly exchangeable with another £10 note. A bearer bond also has this quality.

**Future:** A futures contract is a contract to buy or sell securities or other goods at a future date at a predetermined price. Futures contracts are usually standardised and traded on an exchange.

**Future exposure:** See **Potential exposure**.

**Future value:** The amount of money achieved in the future, including interest, by investing a given amount of money now. See **Time value of money**, **Present value**.

**Futures contract:** A deal to buy or sell some financial instrument or commodity for value on a future date. Unlike a forward deal, futures contracts are traded only on an exchange (rather than **OTC**), have standardised contract sizes and value dates, and are often only **Contract for differences** rather than deliverable.

## G

**G7:** The “Group of Seven” countries, the USA, Canada, UK, Germany, France, Italy and Japan.

**GDP:** Gross domestic product, the value of total output produced within a country’s borders.

**GEMM:** A gilt-edged market maker, a bank or securities house registered with the Bank of England as a market maker in gilts. A GEMM is required to meet certain obligations as part of its function as a registered market maker, including making two-way price quotes at all times in all gilts and taking part in gilt auctions. The Debt Management Office now make a distinction between conventional gilt GEMMs and index-linked GEMMs, known as IG GEMMs.

**General collateral (GC):** Securities, which are not “special”, used as collateral against cash borrowing. A repo buyer will accept GC at any time that a specific stock is not quoted as required in the transaction. In the gilts market GC includes **DBVs**.

**GIC:** Guaranteed investment contract.

**Gilt:** A UK Government sterling denominated, listed security issued by HM Treasury with initial maturity of over 365 days when issued. The term “gilt” (or gilt-edged) is a reference to the primary characteristic of gilts as an investment: their security.

**Gilt-edged market maker:** See **GEMM**.

**GNP:** Gross national product, the total monetary value of a country’s output, as produced by citizens of that country.

**Gross redemption yield:** The same as **Yield to maturity**; “gross” because it does not take tax effects into account.

**GRY:** See **Gross redemption yield**.

## H

**Hedge ratio:** The ratio of the size of the position it is necessary to take in a particular instrument as a hedge against another, to the size of the position being hedged.

**Hedging:** Protecting against the risks arising from potential market movements in exchange rates, interest rates or other variables. See **Cover, Arbitrage, Speculation**.

## I

**IDB:** Inter-Dealer Broker; in this context a broker that provides facilities for dealing in bonds between market makers.

**IG:** Index-linked gilt whose coupons and final redemption payment are related to the movements in the Retail Price Index (RPI).

**Immunisation:** This is the process by which a bond portfolio is created that has an assured return for a specific time horizon irrespective of changes in interest rates. The mechanism underlying immunisation is a portfolio structure that balances the change in the value of a portfolio at the end of the investment horizon (time period) with the return gained from the reinvestment of cash flows from the portfolio. As such, immunisation requires the portfolio manager to offset interest-rate risk and reinvestment risk.

**Implied repo rate:** The break-even interest rate at which it is possible to sell a bond **Futures contract**, buy a **Deliverable bond**, and **Repo** the bond out. See **Cash-and-carry**.

**Implied volatility:** The **Volatility** used by a dealer to calculate an **Option** price; conversely, the volatility implied by the price actually quoted.

**Interbank:** The market in unsecured lending and trading between banks of roughly similar credit quality.

**Interest rate swap:** An agreement to exchange a series of cash flows determined in one currency, based on fixed or **Floating** interest payments on an agreed **Notional** principal, for a series of cash flows based in the same currency but on a different interest rate. May be combined with a **Currency swap**.

**Intermarket spread:** A spread involving futures contracts in one market spread against futures contracts in another market.

**Internal rate of return:** The yield necessary to discount a series of cash flows to an **NPV** of zero.

**ISMA:** The International Securities Market Association. This association drew up with the PSA (now renamed the Bond Market Association) the PSA/ISMA Global Master Repurchase Agreement.

**Issuer risk:** Risk to an institution when it holds debt securities issued by another institution.

**Iteration:** The repetitive mathematical process of estimating the answer to a problem, by trying how well this estimate fits the data, adjusting the estimate appropriately and trying against, until the fit is acceptably close. Used, for example, in calculating a bond's **Yield** from its price.

## J

**Junk bonds:** The common term for high-yield bonds; higher risk, low rated debt.

## K

**Kappa** ( $\kappa$ ): An alternative term to refer to volatility; see **Vega**.

**Knock out/in:** A knock out (in) **Option** ceases to exist (starts to exist) if the underlying reaches a certain trigger level.

## L

**Leverage:** The ability to control large amounts of an underlying variable for a small initial investment.

**Liability:** Probable future sacrifice of economic benefit due to present obligations to transfer assets or provide services to other entities as a result of past events or transactions. Generally classed as either current or long-term.

**LIBID:** The London Interbank Bid Rate, the rate at which banks will pay for funds in the interbank market.

**LIBOR:** The London Interbank Offered Rate, the lending rate for all major currencies up to one year set at 11am each day by the British Bankers Association.

**Libor fixing:** The Libor rate “fixed” by the British Bankers Association (BBA) at 1100 hours each day, for maturities up to one year.

**LIFFE:** The London International Financial Futures and Options Exchange, the largest futures exchange in Europe.

**Limean:** The arithmetic average of Libor and Libid rates.

**Limit up/down: Futures** prices are generally not allowed to change by more than a specified total amount in a specified time, in order to control risk in very volatile conditions. The maximum movements permitted are referred to as limit up and limit down.

**Liquidation:** Any transaction that closes out or offsets a futures or options position.

**Liquidity:** A word describing the ease with which one can undertake transactions in a particular market or instrument. A market where there are always ready buyers and sellers willing to transact at competitive prices is regarded as liquid. In banking, the term is also used to describe the requirement that a portion of a bank’s assets be held in short-term risk free instruments, such as government bonds, T-Bills and high quality **Certificates of Deposit**.

**Loan-equivalent amount:** Description of derivative exposure which is used to compare the credit risk of derivatives with that of traditional bonds or bank loans.

**Lognormal:** A variable’s **Probability distribution** is lognormal if the logarithm of the variable has a normal distribution.

**Lognormal distribution:** The assumption that the log of today’s interest rate, for example, minus the log of yesterday’s rate is normally distributed.

**Long:** A long position is a surplus of purchases over sales of a given currency or asset, or a situation which naturally gives rise to an organisation benefiting from a strengthening of that currency or asset. To a money market dealer, however, a long position is a surplus of borrowings taken in over money lent out (which gives rise to a benefit if that currency weakens rather than strengthens). See **Short**.

**LSE:** London Stock Exchange.

## M

**Macaulay duration:** See **Duration**.

**Mapping:** The process whereby a treasury’s derivative positions are related to a set of risk “buckets”.

**Margin:** Initial margin is **Collateral**, placed by one party with a counterparty at the time of the deal, against the possibility that the market price will move against the first party, thereby leaving the counterparty with a credit risk. Variation margin is a payment or extra collateral transferred subsequently from one party to the other because the market price has moved. Variation margin payment is either in effect a settlement of profit/loss (for example, in the case of a **Futures** contract) or the reduction of credit exposure (for example, in the case of a **Repo**). In gilt **Repos**, variation margin refers to the fluctuation band or

threshold within which the existing collateral's value may vary before further cash or **Collateral** needs to be transferred. In a loan, margin is the extra interest above a **Benchmark** (e.g. a margin of 0.5 per cent over LIBOR) required by a lender to compensate for the credit risk of that particular borrower.

**Margin call:** A request following marking-to-market of a repo transaction for the initial margin to be reinstated or, where no initial margin has been taken to restore the cash/securities ratio to parity.

**Margin default rate:** See **Probability of default**.

**Margin transfer:** The payment of a **Margin call**.

**Market comparables:** Technique for estimating the fair value of an instrument for which no price is quoted by comparing it with the quoted prices of similar instruments.

**Market-maker:** Market participant who is committed, explicitly or otherwise, to quoting two-way bid and offer prices at all times in a particular market.

**Market risk:** Risks related to changes in prices of tradeable macroeconomic variables, such as exchange rate risks.

**Mark-to-market:** The act of revaluing securities to current market values. Such revaluations should include both coupon accrued on the securities outstanding and interest accrued on the cash.

**Matched book:** This refers to the matching by a repo trader of securities repoed in and out. It carries no implications that the trader's position is "matched" in terms of exposure, for example to short-term interest rates.

**Maturity date:** Date on which stock is redeemed.

**Mean:** Average.

**Modified following:** The convention that if a value date in the future falls on a non-business day, the value date will be moved to the next following business day, unless this moves the value date to the next month, in which case the value date is moved back to the last previous business day.

**Money market:** Short-term market (generally up to one year) for financial instruments. See **Capital market**.

**Money-market basis:** An interest rate quoted on an **ACT/360** basis is said to be on a money-market basis. See **Bond basis**.

**Monte Carlo simulation:** Technique used to determine the likely value of a derivative or other contract by simulating the evolution of the underlying variables many times. The discounted average outcome of the simulation gives an approximation of the derivative's value. Monte Carlo simulation can be used to estimate the **Value-at-risk (VAR)** of a portfolio. Here, it generates a simulation of many correlated market movements for the markets to which the portfolio is exposed, and the positions in the portfolio are revalued repeatedly in accordance with the simulated scenarios. This gives a probability distribution of portfolio gains and losses from which the **VAR** can be determined.

**Moosmüller:** A method for calculating the yield of a bond.

**Mortgage-backed security (MBS):** Security guaranteed by pool of mortgages. MBS markets include the US, UK, Japan and Denmark.

**Moving average convergence/divergence:** The crossing of two exponentially smoothed moving averages that oscillate above and below an equilibrium line. (MACD).

## N

**Naked:** A naked **Option** position is one not protected by an off-setting position in the **Underlying**. See **Covered call/put**.

**NAO:** National Audit Office.

**Negative divergence:** When at least two indicators, indexes or averages show conflicting or contradictory trends.

**Negotiable:** A security which can be bought and sold in a **Secondary market** is negotiable.

**Net present value:** The net present value of a series of cash flows is the sum of the present values of each cash flow (some or all of which may be negative).

**NLF:** National Loans Fund, the account which brings together all UK Government lending and borrowing.

**Noise:** Fluctuations in the market which can confuse or impede interpretation of market direction.

**Nominal amount:** Same as **Face value** of a security.

**Nominal rate:** A rate of interest as quoted, rather than the **Effective rate** to which it is equivalent.

**Normal:** A normal **Probability distribution** is a particular distribution assumed to prevail in a wide variety of circumstances, including the financial markets. Mathematically, it corresponds to the probability density function:

$$\frac{1}{\sqrt{2\pi}} e^{-\frac{1}{2}x^2}$$

**Notional:** In a bond futures contract, the bond bought or sold is a standardised non-existent notional bond, as opposed to the actual bonds which are **Deliverable** at maturity. **Contracts for differences** also require a notional principal amount on which settlement can be calculated.

**Novation:** Replacement of a contract or, more usually, a series of contracts with one new contract.

**NPV:** See **Net present value**.

## O

**O/N:** See **Overnight**.

**Odd date:** See **Broken date**.

**Offer:** The price at which a market maker will sell bonds. Also called "ask".

**Off-market:** A rate which is not the current market rate.

**Opening leg:** The first half of a repo transaction.

**Open interest:** The quantity of **Futures** contracts (of a particular specification) which have not yet been closed out by reversing. Either all **Long** positions or all **Short** positions are counted but not both.

**Operational Market Notice:** Sets out the DMO's (previously the Bank's) operations and procedures in the gilt market.

**Operational risk:** Risk of loss occurring due to inadequate systems and control, human error, or management failure.

**Opportunity cost:** Value of an action that could have been taken if the current action had not been chosen.

**Option:** The right (but not the obligation) to buy or sell securities at a fixed price within a specified period.

**Option forward:** See **Time option**.

**OTC:** Over the counter. Strictly speaking any transaction not conducted on a registered stock exchange. Trades conducted via the telephone between banks, and contracts such as FRAs and (non-exchange

traded) options are said to be “over-the-counter” instruments. OTC also refers to non-standard instruments or contracts traded between two parties; for example a client with a requirement for a specific risk to be hedged with a tailor-made instrument may enter into an OTC structured option trade with a bank that makes markets in such products.

**Over the counter:** An OTC transaction is one dealt privately between any two parties, with all details agreed between them, as opposed to one dealt on an exchange – for example, a **Forward** deal as opposed to a **Futures contract**.

**Overborrowed:** A position in which a dealer’s liabilities (borrowings taken in) are of longer maturity than the assets (loans out).

**Overlent:** A position in which a dealer’s assets (loans out) are of longer maturity than the liabilities (borrowings taken in).

**Overnight:** A deal from today until the next working day (“tomorrow”).

## P

**Paper:** Another term for a bond or debt issue.

**Par:** In foreign exchange, when the outright and **Spot** exchange rates are equal, the **Forward swap** is zero or par. When the price of a security is equal to the face value, usually expressed as 100, it is said to be trading at par. A par swap rate is the current market rate for a fixed **Interest rate swap** against **LIBOR**.

**Par yield curve:** A curve plotting maturity against **Yield** for bonds priced at par.

**Parity:** The official rate of exchange for one currency in terms of another which a government is obliged to maintain by means of intervention.

**Pips:** See **Points**.

**Plain vanilla:** See **Vanilla**.

**Points:** The last two decimal places in an exchange rate. For example, when EUR/USD is 1.1910/1.1920, the points are 10/20. See **Bid figure**.

**Preference shares:** These are a form of corporate financing. They are normally fixed interest shares whose holders have the right to receive dividends ahead of ordinary shareholders. If a company were to go into liquidation, preference shareholders would rank above ordinary shareholders for the repayment of their investment in the company. Preference shares are normally traded within the fixed interest division of a bank or securities house.

**Premium:** The forward premium is the amount by which a currency is more expensive, in terms of another currency, for future delivery than for spot (in general, a reflection of interest rate differentials between two currencies). If an exchange rate is “at a premium” (without specifying to which of the two currencies this refers), this generally means that the **Variable currency** is at a premium. See **Discount**.

**Present value:** The amount of money which needs to be invested now to achieve a given amount in the future when interest is added. See **Time value of money**, **Future value**.

**Pre-settlement risk:** As distinct from credit risk arising from intra-day settlement risk, this term describes the risk of loss that might be suffered during the life of the contract if a counterparty to a trade defaulted and if, at the time of the default, the instrument had a positive economic value.

**Price-earnings ratio:** A ratio giving the price of a stock relative to the earnings per share.

**Price factor:** See **Conversion factor**.

**Primary market:** The market for new debt, into which new bonds are issued. The primary market is made up of borrowers, investors and the investment banks which place new debt into the market, usually with their clients. Bonds that trade after they have been issued are said to be part of the secondary market.

**Probability distribution:** The mathematical description of how probable it is that the value of something is less than or equal to a particular level.

**Put:** A put option is an option to sell the commodity or instrument **Underlying** the option. See **Call**.

## Q

**Quanto:** An option that has its final payoff linked to two or more underlying assets or reference rates.

**Quanto swap:** A **Swap** where the payments of one or both legs are based on a measurement (such as the interest rate) in one currency but payable in another currency.

**Quasi-coupon date:** The regular date for which a **Coupon** payment would be scheduled if there were one. Used for price/yield calculations for **Zero-coupon** instruments.

## R

**Record date:** A **Coupon** or other payment due on a security is paid by the issuer to whoever is registered on the record date as being the owner. See **Ex-dividend**, **Cum dividend**.

**Redeem:** A security is said to be redeemed when the principal is repaid.

**Redemption yield:** The rate of interest at which all future payments (coupons and redemption) on a bond are discounted so that their total equals the current price of the bond (inversely related to price).

**Redenomination:** A change in the currency unit in which the nominal value of a security is expressed (in context, from sterling to euro).

**Refer:** The practice whereby a trader instructs a broker to put “under reference” any prices or rates he has quoted to him, meaning that they are no longer “firm” and the broker must refer to the trader before he can trade on the price initially quoted.

**Register:** Record of ownership of securities. For gilts, excluding bearer bonds, entry in an official register confers title.

**Registered bond:** A bond for which the issuer keeps a record (register) of its owners. Transfer of ownership must be notified and recorded in the register. Interest payments are posted (more usually electronically transferred) to the bondholder.

**Registrar's department:** Department of the Bank of England which maintains the register of holdings of gilts.

**Reinvestment rate:** The rate at which interest paid during the life of an investment is reinvested to earn interest-on-interest, which in practice will generally not be the same as the original yield quoted on the investment.

**Repo:** Usually refers in particular to **Classic repo**. Also used as a term to include **Buy/sell-backs** and **Securities lending**.

**Repo rate:** The return earned on a repo transaction expressed as an interest rate on the cash side of the transaction.

**Repurchase agreement:** See **Repo**.

**Return on assets:** The net earnings of a company divided by its assets.



**Return on equity:** The net earnings of a company divided by its equity.

**Reverse:** See **Reverse repo**.

**Reverse repo:** The opposite of a **Repo**.

**Rollover:** See **Tom/next**. Also refers to a renewal of a loan.

**Rump:** A gilt issue so designated because it is illiquid, generally because there is a very small nominal amount left in existence.

**Running yield:** Same as **Current yield**.

## S

**S/N:** See **Spot/next**.

**SAFE:** See **Synthetic** agreement for forward exchange.

**Secondary market:** The market in instruments after they have been issued. Bonds are bought and sold after their initial issue by the borrower, and the marketplace for this buying and selling is referred to as the secondary market. The new issues market is the *primary* market.

**Securities and Exchange Commission (SEC):** The central regulatory authority in the United States, responsible for policing the financial markets including the bond markets.

**Securities lending:** When a specific security is lent against some form of collateral. Also known as stock lending.

**Security:** A financial asset sold initially for cash by a borrowing organisation (the “issuer”). The security is often negotiable and usually has a maturity date when it is redeemed.

**Sell/buy-back:** Simultaneous spot sale and forward purchase of a security, with the forward price calculated to achieve an effect equivalent to a **Classic repo**.

**Settlement:** The process of transferring stock from seller to buyer and arranging the corresponding movement of funds between the two parties.

**Settlement bank:** Bank which agrees to receive and make assured payments for gilts bought and sold by a CGO member.

**Settlement date:** Date on which transfers of gilts and payment occur, usually the next working date after the trade is conducted.

**Settlement risk:** The risk that occurs when there is a non-simultaneous exchange of value. Also known as “delivery risk” and “Herstatt risk”.

**Short:** A short position is a surplus of sales over purchases of a given currency or asset, or a situation which naturally gives rise to an organisation benefiting from a weakening of that currency or asset. To a money market dealer, however, a short position is a surplus of money lent out over borrowings taken in (which give rise to a benefit if that currency strengthens rather than weakens). See **Long**.

**Short date:** A deal for value on a date other than spot but less than one month after spot.

**Simple interest:** When interest on an investment is paid all at maturity or not reinvested to earn interest on interest, the interest is said to be simple. See **Compound interest**.

**Simple yield to maturity:** Bond coupon plus principal gain/loss amortised over the time to maturity, as a proportion of the clean price per 100. Does not take **Time value of money** into account. See **Yield to maturity**, **Current yield**.

**SLA:** Service Level Agreement, in this context between the DMO and service suppliers in the Bank and HM Treasury.

**Special:** A security which for any reason is sought after in the repo market, thereby enabling any holder of the security to earn incremental income (in excess of the General Collateral rate) through lending them via a repo transaction. The repo rate for a special will be below the GC rate, as this is the rate the borrower of the cash is paying in return for supplying the special bond as collateral. An individual security can be in high demand for a variety of reasons, for instance if there is sudden heavy investor demand for it, or (if it is a benchmark issue) it is required as a hedge against a new issue of similar maturity paper.

**Speculation:** A deal undertaken because the dealer expects prices to move in their favour, as opposed to **Hedging** or **Arbitrage**.

**Spot:** A deal to be settled on the customary value date for that particular market. In the foreign exchange market, this is for value in two working days' time.

**Spot/next:** A transaction from **Spot** until the next working day.

**Spread:** The difference between the bid and offer prices in a quotation. Also a strategy involving the purchase of an instrument and the simultaneous sale of a similar related instrument, such as the purchase of a **Call option** at one **Strike** and the sale of a call option at a different strike.

**Square:** A position in which sales exactly match purchases, or in which assets exactly match liabilities. See **Long**, **Short**.

**Standard deviation ( $\sigma$ ):** A measure of how much the values of something fluctuate around its mean value. Defined as the square root of the **Variance**.

**Stock lending:** See **Securities lending**.

**Stock index future:** Future on a stock index, allowing a hedge against, or bet on, a broad equity market movement.

**Stock index option:** Option on a stock index future.

**Stock option:** Option on an individual stock.

**Street:** The "street" is a term for the market, originating as "Wall Street". A US term for market convention, so in the US market is the convention for quoting the price or yield for a particular instrument.

**Strike:** The strike price or strike rate of an option is the price or rate at which the holder can insist on the underlying transaction being fulfilled.

**Strip:** A zero-coupon bond which is produced by separating a standard coupon-bearing bond into its constituent principal and interest components. To strip a bond is to separate its principal amount and its coupons and trade each individual cash flow as a separate instrument ("separately traded and registered for interest and principal"). Also, a strip of **Futures** is a series of short-term futures contracts with consecutive delivery dates, which together create the effect of a longer-term instrument (for example, four consecutive three-month futures contracts as a **Hedge** against a one-year swap). A strip of **FRAs** is similar.

**Swap:** A foreign exchange swap is the purchase of one currency against another for delivery on one date, with a simultaneous sale to reverse the transaction on another value date. See also **Interest rate swap**, **currency swap**.

**Swaption:** An **Option** on an **Interest rate swap**, **Currency swap**.

**Switch:** Exchanges of one gilt holding for another, sometimes entered into between the DMO and a GEMM as part of the DMO's secondary market operations.

**Synthetic:** A package of transactions which is economically equivalent to a different transaction (for example, the purchase of a **Call option** and simultaneous sale of a **Put** option at the same **Strike** is a synthetic **Forward** purchase.)

## T

**T/N:** See **Tom/next**.

**Tail:** The exposure to interest rates over a forward-forward period arising from a mismatched position (such as a two-month borrowing against a three-month loan). A forward foreign exchange dealer's exposure to **Spot** movements.

**Tap:** The issue of a gilt for exceptional market management reasons and not on a pre-announced schedule.

**Term:** The time between the beginning and end of a deal or investment.

**Tick:** The minimum change allowed in a futures price.

**Time deposit:** A non-**Negotiable** deposit for a specific term.

**Time option:** A forward currency deal in which the value date is set to be within a period rather than on a particular day. The customer sets the exact date two working days before settlement.

**Time value of money:** The concept that a future cash flow can be valued as the amount of money which it is necessary to invest now in order to achieve that cash flow in the future. See **Present value**, **Future value**.

**Today/tomorrow:** See **Overnight**.

**Tom/next:** A transaction from the next working day ("tomorrow") until the day after ("next day" – i.e. **Spot** in the foreign exchange market).

**Total return swap:** Swap agreement in which the total return of bank loans or credit-sensitive securities is exchanged for some other cash flow usually tied to **LIBOR**, or other loans, or credit-sensitive securities. It allows participants to effectively go **Long** or **Short** the credit risk of the **Underlying** asset.

**Traded option:** Option that is listed on and cleared by an exchange, with standard terms and delivery months.

**Tranche:** One of a series of two or more issues with the same coupon rate and maturity date. The tranches become fungible at a future date, usually just after the first coupon date.

**Transaction risk:** Extent to which the value of transactions that have already been agreed is affected by market risk.

**Transparent:** A term used to refer to how clear asset prices are in a market. A transparent market is one in which a majority of market participants are aware of what level a particular bond or instrument is trading.

**Treasury bill:** A short-term security issued by a government, generally with a zero **Coupon**.

## U

**Uncovered option:** When the writer of the option does not own the underlying security. Also known as a **Naked** option.

**Undated gilts:** Gilts for which there is no final date by which the gilt must be redeemed.

**Underlying:** The underlying of a futures or option contract is the commodity of financial instrument on which the contract depends. Thus the underlying for a bond option is the bond; the underlying for a short-term interest rate futures contract is typically a three-month deposit.

**Underwriting:** An arrangement by which a company is guaranteed that an issue of debt (bonds) will raise a given amount of cash. Underwriting is carried out by investment banks, who undertake to purchase any part of the debt issue not taken up by the public. A commission is charged for this service.

## V

**Value-at-risk (VAR):** Formally, the probabilistic bound of market losses over a given period of time (known as the holding period) expressed in terms of a specified degree of certainty (known as the confidence interval). Put more simply, the VAR is the worst-case loss that would be expected over the holding period within the probability set out by the confidence interval. Larger losses are possible but with a low probability. For instance, a portfolio whose VAR is \$20 million over a one-day holding period, with a 95% confidence interval, would have only a 5% chance of suffering an overnight loss greater than \$20 million.

**Value date:** The date on which a deal is to be consummated. In some bond markets, the value date for coupon accruals can sometimes differ from the settlement date.

**Vanilla:** A vanilla transaction is a straightforward one.

**VAR:** See **Value-at-risk**.

**Variable currency:** Exchange rates are quoted in terms of the number of units of one currency (the variable or counter currency) which corresponds to one unit of the other currency (the **Base currency**).

**Variance ( $\sigma^2$ ):** A measure of how much the values of something fluctuate around its mean value. Defined as the average of  $(\text{value} - \text{mean})^2$ . See **Standard deviation**.

**Variance-covariance methodology:** Methodology for calculating the **Value-at-risk** of a portfolio as a function of the **Volatility** of each asset or liability position in the portfolio and the correlation between the positions.

**Variation margin:** The band agreed between the parties to a repo transaction at the outset within which the value of the collateral may fluctuate before triggering a right to call for cash or securities to reinstate the initial margin on the repo transaction.

**Vega:** The change in an option's value relative to a change in the **Underlying's** volatility.

**Volatility:** The **Standard deviation** of the continuously compounded return on the **Underlying**. Volatility is generally annualised.

## W

**Warrant:** A security giving the holder a right to subscribe to a share or bond at a given price and from a certain date. If this right is not exercised before the maturity date, the warrant will expire worthless.

**Warrant-driven swap:** Swap with a warrant attached allowing the issuer of the fixed-rate bond to go on paying a floating rate in the event that they exercise another warrant allowing them to prolong the life of the bond.

**When-issued trading:** Trading a bond before the issue date; no interest is accrued during this period. Also known as the "grey market".

**Write:** To sell an option is to write it. The person selling an option is known as the **Writer**.

**Writer:** The same as "seller" of an **Option**.

## X

**X:** Used to denote the strike price of an option; sometimes this is denoted using the term  $K$ .

## Y

**Yield:** The interest rate which can be earned on an investment, currently quoted by the market or implied by the current market price for the investment – as opposed to the **Coupon** paid by an issuer on

a security, which is based on the coupon rate and the face value. For a bond, generally the same as yield to maturity unless otherwise specified.

**Yield curve:** Graphical representation of the maturity structure of interest rates, plotting yields of bonds that are all of the same class or credit quality against the maturity of the bonds.

**Yield-curve option:** Option that allows purchasers to take a view on a yield curve without having to take a view about a market's direction.

**Yield-curve swap:** Swap in which the index rates of the two interest streams are at different points on the yield curve. Both payments are refixed with the same frequency whatever the index rate.

**Yield to equivalent life:** The same as **Yield to maturity** for a bond with partial redemptions.

**Yield to maturity:** The **Internal rate of return** of a bond – the yield necessary to discount all the bond's cash flows to an NPV equal to its current price. See **Simple yield to maturity**, **Current yield**.

**YTM:** See **Yield to maturity**.

## Z

**Zero-coupon:** A zero-coupon security is one that does not pay a **Coupon**. Its price is correspondingly less to compensate for this. A zero-coupon **Yield** is the yield which a zero-coupon investment for that term would have if it were consistent with the **Par yield curve**.

**Zero-coupon bond:** Bond on which no coupon is paid. It is either issued at a discount or redeemed at a premium to face value.

**Zero-coupon swap:** Swap converting the payment pattern of a zero-coupon bond, either to that of a normal, coupon-paying fixed-rate bond or to a **Floating rate**.

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