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Editors

Sustaining Entrepreneurship and Economic Growth

Lessons in Policy and
Industry Innovations from
Germany and India

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Sustaining Entrepreneurship and Economic Growth

INTERNATIONAL STUDIES IN ENTREPRENEURSHIP

Series Editors:

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Preface

Entrepreneurship has been recognized as a major determinant of economic growth in most developed countries. Increased entrepreneurial activity has resulted in an environment of sustainable economic growth and controlled unemployment in North America over the last 20 years. In Europe and Asia as well, academic researchers and policy makers have realized the potential of entrepreneurship to improve growth rates and decrease unemployment. Usually, in industrialized countries, the debate on "entrepreneurship" revolves around invention and the subsequent creation of new ventures in innovative industries.

Keeping in view the growing recognition of entrepreneurship in the field of economics and its relevance to both developed and developing economies, the Max Planck Institute of Economics conducted the First Max Planck India Workshop jointly with the Indian Institute of Science in March 2006. This event evinced considerable interest from academics across the world. The aim of this workshop was to reunite academic work on entrepreneurship that has been conducted in Germany, in the US and in India, to explore common issues and differences in the dynamics of entrepreneurship in these countries.

The workshop has been part of a larger co-operation on science and technology between the Max Planck Society and the Indian Department of Science and Technology that was signed in December 2004 by Professor Dr. Peter Gruss, President of the Max Planck Organization on the German side and Professor Dr. V. S. Ramamurthy, State Secretary at the Indian Department of Science and Technology on the Indian side, together with the German Chancellor Gerhard Schroeder and the Indian Minister for Science and Technology, Kapil Sibal.

Jena,
March 2008

Max Keilbach
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David Audretsch

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Introduction: Entrepreneurship and Innovation in Germany and India

David B. Audretsch, Max Keilbach, and Jagannadha Pawan Tamvada

As more and more research studies suggest that a good entrepreneurial environment leads to sustained economic progress, the necessity to shift from a managed economy to entrepreneurial economy has become the focal point of policy debate. Academic research on developed countries has scientifically evaluated the role of entrepreneurship on economic growth, market expansion, innovation and reducing unemployment. In this research, it has consistently been shown that regions or industries with higher rates of entrepreneurship show higher levels of innovation and economic growth. Consequently, most European countries are realizing the potential of entrepreneurship to improve growth rates and reduce the unemployment levels. They are introducing policy measures to strengthen their entrepreneurship capital.

The literature on entrepreneurship and innovation however ignored developing countries for a long time. Nevertheless, entrepreneurship plays an important role in these countries as well. For instance, Bangalore has become "India's Silicon Valley" by promoting high-tech entrepreneurship. It has one of the highest growth rates of per capita income in India. Cities like Hyderabad and Gurgaon have adopted strategies to encourage entrepreneurship and are experiencing high growth rates. China's growth can be traced back to the economic reforms that started in 1978 that allowed the formation of many rural enterprises and private businesses. These examples confirm the role entrepreneurship can play in economic growth. Understanding their successful transformation may provide some solutions to critical economic stagnation problems developed countries in Europe are facing.

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This collected volume brings together articles by eminent scholars in Germany, the US and India with an aim to provide a coherent understanding of the entrepreneurial processes and to find potential policy implications for sustaining entrepreneurial activity in these countries. The first part presents theoretical models on the role of entrepreneurship in India and Germany. The second part consists of empirical studies on the impact of entrepreneurship in India and Germany. The third part presents a set of studies of different industries in India and Germany and of the role of entrepreneurship in these industries.

Many empirical studies suggest that entrepreneurship is a key determinant of economic growth in developed countries. The first chapter by Keilbach and Sanders builds a theoretical model that formally proves this point. Their model suggests that while introduction of new goods is a function of large firms, innovations that improve quality are essentially achieved by entrepreneurs. When labor is not allocated to either of the sectors, the innovation rate decreases and hence entrepreneurship becomes an important determinant of the innovation and growth processes. Using structural equation modeling and data on German manufacturing industry, Audretsch, Boente and Keilbach empirically show that entrepreneurship capital is positively related to economic performance. Their chapter suggests that entrepreneurship plays a role in the economic processes through its latent role in knowledge spillovers.

Academic entrepreneurship is one of the channels through which commercialization of knowledge takes place. In chapter two, Rao presents a theoretical model that attempts to derive conditions under which scientists at public research institutions decide to commercialize their inventions through either of the two institutional mechanisms: creation of new firms and licensing the use of patented or proprietary knowledge to private firms. This chapter suggests that scientists are likely to start new firms when the expected value of the discovery is very high or if patent protection for proprietary knowledge is low. Furthermore, it is also shown that when scientists need to be extensively involved in the transfer of informal knowledge to the private firms, they have greater motivation to start firms. The chapter by Bhatt and Narayanan suggests that the entrepreneur decides on an appropriate technological strategy, whether to choose in-house R&D or to import disembodied technology and so on, based on the nature of ownership of the firm, the scale of the operation (market share of firm), the knowledge earned over time (age of firm), the internal financial resources (profit margins of the firm) and the degree of internalization (vertical integration of the firm).

Many studies suggest that the availability of finance is an essential determinant of entrepreneurial activity in an economy. Bala Subrahmanya and Majumdar, in their chapter, examine the link between the growth in the credit advances from commercial financial institutions to the small firms in India and their performance both before as well as after economic liberalization. On the one hand, they find that credit could have been misdirected to firms that were not very productive during the pre-liberalization period and this could be a reason for an insignificant relationship between credit advances and performance of small firms. On the other hand, they suggest that proper utilization of bank finance and improved credit

delivery systems could explain the improvements in the performance of small firms in the post-liberalization period, although the advances granted to such firms, relative to their production, decreased over time. One of the channels through which entrepreneurs acquire finance is through venture capitalists. The chapter of Khaturia and Tiwari examines the determinants of entrepreneurs obtaining venture capital. Their study on biotechnology firms in India suggests that venture capitalists are more likely to fund ventures that have alliances but do not diversify much. Furthermore, firms that are members of science parks are also found to have a higher likelihood of obtaining venture finance. However, the study of Taeube suggests that ethnic networks and diversity are more important as determinants of technology entrepreneurship in India, while venture capital has no significant effect.

Thakur, Chittor and Perumal compare the role of demographics in entrepreneurship in Germany and India. Their study suggests that while in-migration and population structure can explain the level of entrepreneurial activity when both countries are considered together, there is no statistically significant relationship between education levels and entrepreneurship in the regions. However, when the data on Germany and India are analyzed separately, they find that higher education has a positive effect on entrepreneurial activity in India, while it has no effect in Germany. However, this contrasts with the results of the chapter by Tamvada(a), based on large-scale NSSO datasets, which state that education decreases the likelihood of being self-employed in India. One reason for this difference could be that the definition of entrepreneurial activity is different in the two studies. While Thakur et al. use the relative share of firms divided by the population in a region as a measure, Tamvada(a) uses self-employment choice in a micro setting. Thus the definition of entrepreneurial activity leads to contrasting results for education. In another comparative study between Germany and India, Tamvada(b) compares the environment in Germany and India, with regard to entrepreneurship. The results suggest that the two countries are similar in some aspects such as entrepreneurial reward systems, social attitudes and entrepreneurial education, although they are very different on some aspects such as infrastructure and public policy.

Two chapters highlight how public policy might fail in the entrepreneurial context. Fier and Heneric examine the case of the biotechnology industry in Germany and suggest that the R&D policy ensured that public funds are channeled to firms that were averse to taking risks and had good credit histories, while firms that were more inclined to take up risky ventures, had less likelihood of getting public funds, as they mostly had poor credit histories. Rajeev's study shows that a policy of subsidy and protection in the foundry industry has resulted in risk averse entrepreneurial attitudes and low-technology-based ventures in the state of West Bengal, in sharp contrast to the growth of technology-based firms in the same sector in another state of India, Tamil Nadu. The last two chapters summarize the main findings of these studies and present concluding remarks.

The chapters suggest that the dynamics as well as the motivation and impact of entrepreneurship differ in developing and industrialized countries. Thus, it is meaningful to evaluate the entrepreneur's motivation in order to distinguish between "necessity-based entrepreneurship" which concerns start-up activities for personal

needs of the entrepreneur and "opportunity-based entrepreneurship" which refers to realizing business opportunities. These chapters show that when considering opportunity-based high-tech or "innovative entrepreneurship" (that is, start-ups in high-tech and innovative industries), India and industrialized countries show similar structure and dynamics. The countries are similar in terms of venture capital funding, export orientation and growth potential of innovative firms. Innovative entrepreneurship serves in both regions as the main driver of change and of economic restructuring.

Taken together, these chapters provide a compelling view of why entrepreneurship matters not just in the context of the most highly developed countries such as Germany but also in the developing country context, such as India. These papers show that entrepreneurship is a driving force for economic growth and progress across a broad spectrum of economic development contexts. This book opens the door for developing and pursuing research on the key role that entrepreneurship plays in generating growth, development and competitiveness in the global economy.

Chapter 1
The Contribution of Entrepreneurship to Economic Growth

Max Keilbach and Mark Sanders

> *It has long been recognized that the entrepreneurial function is a vital component in the process of economic growth.*
> William J. (Baumol, 1968, p. 65)

1.1 Introduction

1.1.1 The Economic Function of Entrepreneurship

When Baumol (1968) made the above observation he went on to lament that economic theory to that day systematically ignored the entrepreneur and something should be done about that. Now, 40 years later, there are few economists that would deny the importance of the entrepreneur in modern, innovative and growing economies. But as a recent survey by Bianchi and Henrekson (2005) has shown, widespread sympathy and recognition has not led to a successful entry in mainstream economic models of growth and innovation. One possible reason for this is the multitude of functions that entrepreneurs have been proposed to perform in capitalist economies.

Walras (1874) (and later Kirzner, 1973) considered the function of the entrepreneur as seeking arbitrage opportunities. As such, the entrepreneur is the driving force behind the tâtonnement process that leads to the general equilibrium in the Walrasian model. Once the equilibrium is attained, however, the entrepreneur is no

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longer interesting and this is presumably why the usual analysis of equilibria seems independent of the entrepreneurial function.

Keynes (1920, Chapter VI) in his analysis of the recovery of the European economy after the Treaty of Versailles considered entrepreneurs as "*the active and constructive element in the whole capitalist society*," stressing their importance in organizing the recovery.

Marshall (1920), in the fourth book of his *Principles*, considered four "agents of production": land, labor, capital and organization. And he understood "organization" in a structural sense (i.e. in the sense that the notion "industrial organization" reflects) but also in the sense of an activity. Referring to entrepreneurs as "business men" or "undertakers" he states that:

> They [i.e. the entrepreneurs] *"adventure" or "undertake" its risks* [i.e. the risks of production]*; they bring together the capital and the labour required for the work; they arrange or "engineer" its general plan, and superintend its minor details. Looking at business men from one point of view we may regard them as a highly skilled industrial grade, from another as middlemen intervening between the manual worker and the consumer.* Marshall (1920, p. 244)

Hence for Marshall, the function of the entrepreneur is to organize and control the production process and to bear the risks involved with it. This function of the entrepreneur was also implicit in the work of Hawley (1893) and even Smith (1776).[1] Knight (1921) developed on this work and distinguished between (calculable) risk and (incalculable) uncertainty and saw the main function of the entrepreneur in dealing with the uncertainty that the introduction of new goods to a market entails. Hence Knight expanded the Marshallian function of the entrepreneur by explicitly linking it to the introduction of new goods. But once more, once production is organized and running smoothly, the entrepreneurial function fades and profit maximization takes over.

Schumpeter (1911, 1942) then really pushed the idea of a central role for the entrepreneur in capitalist economies. He saw the function of the entrepreneur in the "*recognition and realization of new economic opportunities*," where opportunities were not only potential products but also potential production processes and opportunities in marketing and reorganization. By considering novelty as a driver of opportunity, the notions risk and uncertainty are of course implicitly part of the entrepreneurial function. Hence, in summary, this literature considers entrepreneurs as agents who seek opportunities in the form of arbitrage or potential innovations, who organize and control the exploration of this opportunity and who are willing to bear the risk of doing so. In short they are the agents of (radical) change.

In an innovation-oriented or knowledge-based economy, the function of opportunity recognition and taking the risk of realizing it becomes more prominent. The act of the entrepreneur is no longer a short preface to static equilibrium but an essential source of competitiveness in a dynamic economic system.[2] Baumol (2002b) distinguished this entrepreneurial function explicitly from the role of larger incumbent corporations who are rather involved in the routine processes of large scale innovation. These processes seem quantitatively more important as they are easier to measure. R&D expenditure and the number of patents generated are larger and

so are the resulting job creation and value added. However, a number of systematic studies have provided evidence that breakthroughs and new products are rather introduced by small and young firms, i.e. by entrepreneurs.[3] In that sense Baumol (2002b) refers to innovation as an integrated process based on a division of labor between small firms, who launch new products and introduce new technologies, and large firms, who take on these ideas and develop them. Hence entrepreneurial firms and large firms coexist in what Baumol (2002a) calls a "*David-Goliath Symbiosis*." In that respect, entrepreneurship plays an important role for the economic dynamics and for the growth process in a modern economy. Failing to understand entrepreneurship is failing to understand modern economic growth. Before we present a model in which that division of labor is formalized, let us first consider the existing models of economic growth and show how our model augments them.

1.1.2 Modeling Entrepreneurship as a Conduit for Knowledge Spillovers

Endogenous growth theory explicitly models the creation of innovations by introducing a dedicated knowledge-generating sector (R&D or education).[4] One of the main assumptions underlying this theory is that knowledge behaves like a public good, i.e. it is non-exhaustive and non-excludable. This implies that the stock of existing knowledge and the newly created knowledge is available (i.e. spills over) automatically to all economic agents. In that respect, the properties of knowledge differ fundamentally from the "traditional" production factors, i.e. capital and labor.

The public goods assumption implicitly suggests that all new knowledge is fully commercialized and applied in the production process. However, as Arrow (1962) pointed out, new knowledge differs from the traditional production factors by its public goods characteristics and is also inherently uncertain. By uncertainty, Arrow understood the fact that it is a priori unknown if newly generated knowledge can be transferred successfully into a viable innovation, be it a new product or any other innovation. Indeed, one can think of the stream of new knowledge arriving at a certain time period as involving different levels of uncertainty. For some of the new knowledge, its usefulness, and hence the possibility of transforming it into a new product, is obvious to all agents involved in the production process. Think for example of quality improvements of existing products. On the other end of the "uncertainty spectrum" is new knowledge whose usefulness is not obvious at all, i.e. this knowledge is rather distant from what we know and represents a radical innovation. Here, we can think of new knowledge that can be either very useful, indeed potentially revolutionizing,[5] or useless, indeed totally inapplicable. This means that with increasing uncertainty of the new knowledge, the *variance* of the value of new knowledge increases.

The uncertainty involved in such innovations cannot be diversified away or resolved by gathering additional information. At the individual level, this implies

that an entrepreneur develops a vision on opportunities that are based on the untapped part of the public available knowledge and then just tries. If the entrepreneur guesses that the potential (risk adjusted) returns to those products are superior to what he would earn as an employee, he will engage into starting up a new venture to realize his vision. By doing so, he explores new knowledge that otherwise would remain unexplored, and is part of the knowledge spillover process in the economy (Audretsch et al. (2006) denote this process the *Knowledge Spillover Theory of Entrepreneurship*).

Summarizing this discussion, we state that the function of the entrepreneur is to seek arbitrage and innovation opportunities, to pursue these opportunities and to bear the risk involved in this enterprise.

In this chapter we present a model in which the entrepreneurial function is made central to the process of economic growth. The entrepreneurs, however, do not drive R&D (or education) off the stage. Instead they can be positioned clearly between knowledge, that for simplicity is assumed to evolve gradually and autonomously, and product improvements, that are the domain of profit-driven corporate R&D workers. Entrepreneurs, in our model, are the agents that combine ideas from the knowledge stock into opportunities and then bring new products to the market. The common knowledge stock also benefits quality improving R&D. Thereby we retain the public goods properties of knowledge. Section 1.2 presents the model. Section 1.3 analyzes the implications of the model and highlights the role of entrepreneurs by comparing equilibrium dynamics with and without entrepreneurial activity. It is shown that sustainable growth does not require entrepreneurs but is greatly enhanced by it. Section 1.4 concludes.

1.2 The Model

We consider an economy in which the population is active in one of three market activities, i.e.

$$Pop = L + R + N \tag{1.1}$$

where Pop is the population involved in the economic process, L is labor involved in production, R is employees involved in R&D and N is individuals acting as entrepreneurs. We assume homogenous, risk neutral agents that only care about expected income and so all activities must generate the same expected flow of income in equilibrium. Laborers produce n diversified and existing products. Each product i has a certain quality q_i assigned and comes with a corresponding price p_i and consumption level c_i. R&D workers improve existing products by increasing the quality parameter for product i, whereas entrepreneurs introduce new varieties and increase n. For these activities to be valuable we need consumers to be willing to postpone consumption (in order to finance R&D and entrepreneurial ventures) and have a preference for variety and quality.[6] Hence we assume that on the basis

of a standard Dixit-Stiglitz love-of-variety instant utility function, augmented with variety specific quality parameter, consumers solve

$$\max_{c_i} : \left(\int_0^n q_i^{1-\alpha} c_i^{\alpha} di \right)^{1/\alpha} \quad \text{s.t.} \quad \int_0^n c_i p_i di \leq E \tag{1.2}$$

with $0 \leq \alpha \leq 1$. E is expenditure on consumption. It can be verified in the utility function that economic growth can come from three distinct sources. Variety expansion, quality improvement and regular increases in consumption volumes increase the utility index over time. To derive the instant global demand functions for all current and future goods in this CES-utility function is straightforward:[7]

$$c_i^D = q_i \left(\frac{p_i}{P} \right)^{\frac{1}{\alpha-1}} \frac{E}{P} \quad \text{where} \quad P \equiv \left(\int_0^n p_i^{\frac{\alpha}{\alpha-1}} q_i di \right)^{\frac{\alpha-1}{\alpha}} \tag{1.3}$$

where P is a quality adjusted exponentially weighted price index that can be defined as the minimum cost of one utility.

1.2.1 Producing Sector

Production takes place under monopolistic competition such that producers can set prices. At every point in time they take demand and the quality of their product as given. Hence producers solve

$$\max : \pi_i = c_i \cdot p_i - w \cdot l_i \tag{1.4a}$$
$$s.t. : c_i = c_i^D \tag{1.4b}$$
$$s.t. : y_i = b l_i \tag{1.4c}$$

π_i being profits of firm i, w is the wage level and l_i is the labor force employed by i to produce c_i. Equation (1.4b) makes sure that the market clears and equation (1.4c) is a production function with labor as a single input. This condition excludes the possibility for steady state growth from increases in production volumes as the productivity parameter, b, is given and the level of employment in equilibrium is fixed by the absence of population growth in the model. Solving the set of equation (1.4) yields the equilibrium price of product i

$$p_i = \frac{w}{\alpha b} \tag{1.5}$$

and the equilibrium profit of producing it

$$\pi_i = \frac{(1-\alpha)Eq_i}{nQ} \quad \text{where} \quad Q \equiv \frac{1}{n} \int_0^n q_i di \tag{1.6}$$

Equation (1.6) makes clear that the profit of product i, π_i, increases with its quality q_i, providing firms with an incentive to do R&D. *Positive* profits will create

an incentive to enter the market, i.e. to propose a new product with a given initial quality and with unknown demand. We denoted agents that do so as entrepreneurs.

1.2.2 Knowledge, R&D and Entrepreneurship

Consider K, the level of the existing body of knowledge in the economy. As we are not primarily interested in the sources of growth but rather want to focus on the role of the entrepreneur in economic growth, we assume that K grows at an exogenously given rate g.[8] Knowledge has two impacts in our model.

First, knowledge positively affects the increase of quality of existing products in the R&D process. We specify this activity as

$$\dot{q}_i = h(KR_i)^\gamma \tag{1.7}$$

where $0 \geq \gamma \geq 1$ and h are parameters and a dot over the variable signifies a time derivative. K is the existing body of knowledge in the economy that augments R_i, the level of R&D effort in firm i. The marginal productivity of effective R&D is decreasing in the level of R&D effort and knowledge itself. Note also that the rate of quality improvement inevitably decreases in the level of quality achieved. Quality improvement is thereby effectively excluded as a source of steady state growth in this equation. The rate of R&D labor augmentation that emanates from exogenous knowledge growth is exactly offset by the spreading of a given number of R&D workers over a growing number of firms. The result is a constant increment in quality that vanishes in relative terms. Equation (1.7) thus deviates from standard quality ladder models, where a given level of effort yields a constant rate of quality improvement. We feel, however, that our assumption can be justified as improving quality on already high quality products is typically harder than thinking up quality improvements on low quality products.

The second role of knowledge in our model is to determine the number of potential products n^P. Consider n^P as the number of *opportunities* that can be developed out of the current state of knowledge K. We assume:

$$n^P = \xi K \tag{1.8}$$

where ξ is a parameter. Opportunities include unrealized as well as realized products, i.e. $n \subset n^P$. However, as long as $n < n^p$, there exist unexploited opportunities and therefore room for entrepreneurial activity. By the act of starting a new venture, an entrepreneur introduces a new product in the market. Hence he is developing a previously unrealized idea out the pool of potential products n^P. Formally this activity can be represented by:

$$\dot{n} = a(n^P - n)N^\beta \tag{1.9}$$

where $0 \geq \beta \geq 1$ is a parameter and N is the level of aggregate entrepreneurial activity. Note that this equation introduces strong diminishing returns with respect to n as the marginal productivity of the entrepreneur falls to 0 when all opportunities are exploited, i.e. if $n^P - n \rightarrow 0$. Equation (1.9) therefore implies that variety expansion in the model is restricted in the long run to the rate at which knowledge expands (at rate g, by equation (1.8)).

The fact that profits are made by incumbent firms implies that there is an incentive to enter the market, i.e. to start up a new venture. By the symmetry among all varieties the value of realizing a new commercial opportunity is given by the expected discounted profit flow that any product i yields at some initial quality level q_{i0}, which can be written as:

$$v_n(t) = \int_t^\infty e^{-r(\tau - t)} \pi_i(q_{i0}, \tau) d\tau \qquad (1.10)$$

Here uncertainty potentially enters the model. q_{i0} will be known only when the product is first introduced as it reflects consumers' valuation of the product quality. From equation (1.6) we also see that increasing variety, n, and average quality, Q, erode the profits of firms after introduction. As it is also unknown ex ante how fast competitors will improve the relative quality of their products, how fast variety expands and how fast consumption expenditure grows; the rate of profit erosion is also unknown.

But for now we abstract from any uncertainty that is inherent to the introduction of new products to the market to illustrate the essential mechanisms in the model. Hence we assume that q_{i0} is a known parameter and entrepreneurs form rational expectations, which implies that they have on average correct expectations on future profit erosion rates.[9] As we will show below, they are constant in steady state equilibrium and hence rational expectations imply that entrepreneurs expect constant profit erosion rates. In that case we show in the Appendix that the marginal value of a business opportunity equation (1.10) can be rewritten to:

$$v_n(q_{i0}, t) = \frac{\pi_i(q_{i0}, t)}{r - \dot{E}/E + \dot{Q}/Q + \dot{n}/n} = \frac{(1 - \alpha) E Q^{-1} q_{i0} n^{-1}}{r - \dot{E}/E + \dot{Q}/Q + \dot{n}/n} \qquad (1.11)$$

Equation (1.11) states that the instant profit flow π_i is discounted against the interest rate plus the rate of average quality improvement plus the introduction rate of new products by entrepreneurs, which by equation (1.6) is equal to the rate of profit erosion due to variety expansion and quality improvements in substitutes.[10] This value is not augmented by the fact that an incumbent can improve his own quality parameter because we assume that this is not costless. In other words, in equilibrium the investments required to make such quality improvements will exhaust the additional discounted profits that result from such improvements.

This assumption and the assumption on limited variety expansion serve to tie down the steady state growth rate. No sustainable long run growth is possible without variety expansion, which is impossible without an expanding set of opportunities and knowledge base and the entrepreneurial activity that converts opportunities into

realities. It thus implies that entrepreneurship is an essential contributor to long term growth in the model, even if it cannot be labeled the ultimate source (which is exogenous knowledge expansion). As we do not aim to explain growth itself but rather illuminate the role of entrepreneurs in transforming knowledge accumulation into economic development, we feel that these assumptions are justified in the context of our model. See Jones (2005) on extensions that endogenize the growth of the knowledge stock itself.

The value of adding to the quality index at the margin is given by the derivative of equation (1.11) with respect to q_i. As the effect of one product's quality index on Q is negligible we obtain:

$$v_q(q_i,t) = \frac{1}{r - \dot{E}/E + \dot{Q}/Q + \dot{n}/n} \frac{d\pi_i(q_i,t)}{dq_i} = \frac{(1-\alpha)EQ^{-1}n^{-1}}{r - \dot{E}/E + \dot{Q}/Q + \dot{n}/n} \qquad (1.12)$$

1.2.3 Equilibrium

The equilibrium in the model requires the market clearing conditions for labor, entrepreneurship and research. If we assume that the opportunity costs for entrepreneurs and R&D workers are given by the general wage level, we can calibrate the productivity parameters, a, b and h, to obtain a reasonable allocation of labor over the various activities in the economy. Of course that implies that entrepreneurs, R&D workers and production workers are perfect substitutes, which we certainly do not wish to claim. Still, as long as we assume that the wage in production provides the opportunity costs to R&D workers and entrepreneurs and there is free entry in both occupations, the result is similar as the production wage puts a floor in the marginal revenue of engaging in entrepreneurial activity and doing research.

The demand for labor can be derived from inverting production function equation (1.4c), and substituting for quantities using demand in equation (1.3) and prices in equation (1.5) yields:

$$l_i = \frac{1}{n} \frac{\alpha E}{w} \frac{q_i}{Q} \qquad (1.13)$$

Integrating over all n yields the aggregate labor demand for production:

$$L = \frac{\alpha E}{w} \qquad (1.14)$$

To obtain the demand for entrepreneurship and R&D, the marginal value product value of these activities is set equal to the wage level w. Assuming all entrepreneurs expect to enter the market at the same quality level and rearranging yields:

$$N = \left(\frac{w}{a\beta}\right)^{\frac{1}{\beta-1}} v_n(q_{i0},t)^{\frac{1}{1-\beta}} (\xi K - n)^{\frac{1}{1-\beta}} \qquad (1.15)$$

It is worth noting that entrepreneurial activity is negatively related to the wage in production and positively related to the the marginal value of a business opportunity v_n. From equation (1.11) we know that the equilibrium level of N increases with the profit level and with the growth rate of E but decreases with the growth rate of Q and n. In addition N responds positively to increases in the knowledge stock. The intuition is that more knowledge makes entrepreneurs more likely to succeed.

Similarly, for the demand for R&D employees we find for incumbent firm i:

$$R_i = \left(\frac{w}{h\gamma}\right)^{\frac{1}{\gamma-1}} v_q(q_i,t)^{\frac{1}{1-\gamma}} K^{\frac{\gamma}{1-\gamma}}$$

which, integrated over n yields:

$$R = \left(\frac{w}{h\gamma}\right)^{\frac{1}{\gamma-1}} v_q(q_i,t)^{\frac{1}{1-\gamma}} n K^{\frac{\gamma}{1-\gamma}}. \tag{1.16}$$

Hence the level of R&D activity is also negative in the general wage level and positive in the knowledge stock. Also it responds positively to higher expenditure growth and negatively to increases in the average quality level. However, from equation (1.12) we know that R does not respond to the level of profits but to the marginal increase in profit that a quality improvement allows. In addition, the number of existing varieties now has a positive impact as more varieties imply more varieties that need quality enhancing R&D.

As equations (1.14), (1.15) and (1.16) are all decreasing in the wage, there is a unique wage level that clears the labor market. This is illustrated in Figure 1.1. Due to the different elasticities of the curves, however, it is not possible to compute an
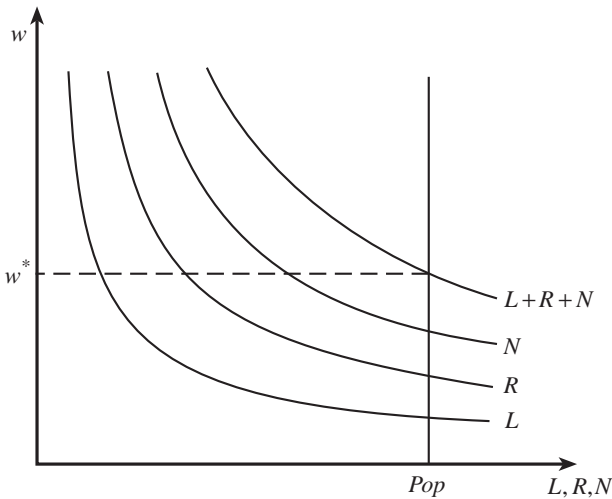
Fig. 1.1 Equilibrium wage level

analytical solution for the equilibrium wage. To prove the existence of a steady state equilibrium, however, this is not required. We can infer its existence from assuming its properties and proving that these assumptions yield a stable equilibrium in the labor market.

1.2.4 Steady State

For the steady state to be stable, the allocation of *Pop* to the aggregates L, R and N must be stable. This implies that

$$\frac{\dot{L}}{L} = \frac{\dot{R}}{R} = \frac{\dot{N}}{N} = 0 \tag{1.17}$$

Given that the population does not grow, the level of production, research and entrepreneurship has to be constant in the steady state. Taking time derivatives and computing the growth rate of equations (1.14), (1.15) and (1.16) then yield the following conditions for the steady state:

$$\frac{\dot{E}}{E} = \frac{\dot{w}}{w} \tag{1.18a}$$

$$\frac{\xi \dot{K} - \dot{n}}{\xi K - n} = \frac{\dot{Q}}{Q} + \frac{\dot{n}}{n} \tag{1.18b}$$

$$\gamma \left(\frac{\dot{K}}{K} - \frac{\dot{n}}{n} \right) = \frac{\dot{Q}}{Q} \tag{1.18c}$$

Using the fact that in any steady state the growth rate of n (the number of varieties) must be equal to the growth rate of n^P (the number of opportunities) and therefore equal to the growth rate of K (the knowledge stock), implies that the difference between K and n grows at the same rate g. Combining this with the set of equations (1.18) yields the results that a steady state may exist as long as

$$\frac{\dot{w}}{w} = \frac{\dot{E}}{E} = r - \rho; \quad \frac{\dot{K}}{K} = \frac{\dot{n}^P}{n^P} = \frac{\dot{n}}{n} = g \quad \text{and} \quad \frac{\dot{Q}}{Q} = 0 \tag{1.19}$$

Normalizing the expenditure for one unit of utility to $E = 1$ yields the growth rate of utility in the economy

$$g_U = -\frac{\dot{P}}{P} = \frac{1 - \alpha}{\alpha} g \tag{1.20}$$

Given conditions equation (1.19) for the steady state, we derive from equation (1.9) that the total level of entrepreneurial activity in the steady state, N^{SS}, must be equal to

$$N^{SS} = \left(\frac{g}{a} \frac{n}{n^P - n} \right)^{1/\beta} \tag{1.21}$$

which states that N^{SS} increases in g, the growth rate of knowledge, and therefore the growth rate of potential products (from equations (1.19)). On the other hand, the level of the steady state of N increases as n approaches n^P. The interpretation is that as the number of new varieties in the model approaches its maximum value, the level of entrepreneurship has to increase to maintain the equilibrium rate of $\dot{n}$ (from equation (1.9)).

In a similar way, we derive from equation (1.7) the steady state level of R as

$$R^{SS} = \frac{n}{K}\left(\frac{gQ}{h}\right)^{1/\gamma} \tag{1.22}$$

And the steady state demand for labor, L^{SS} can then be derived from equation (1.1).

$$L^{SS} = Pop - N^{SS} - R^{SS} \tag{1.23}$$

1.2.5 Dynamic Properties of the Steady State

To analyze the dynamic properties of the model, we derive the laws of motion for Q, n and K. The formal derivation of these equations is given in the Appendix. There we show, that the system will converge to a stable, non-trivial equilibrium in the $(Q, n/K)$ space, i.e. a point with positive long term growth rate of utility and with a positive average quality of the products in the economy. Figure 1.2 depicts this dynamic equilibrium.

The figure shows that if n/K lies above the steady state level for a given level of Q, the marginal productivity of entrepreneurial activity is lower and hence the level of entrepreneurial activity will be lower, causing the growth rate of n to fall relative to g and n/K drops. Similarly, when the average level of quality, Q, increases
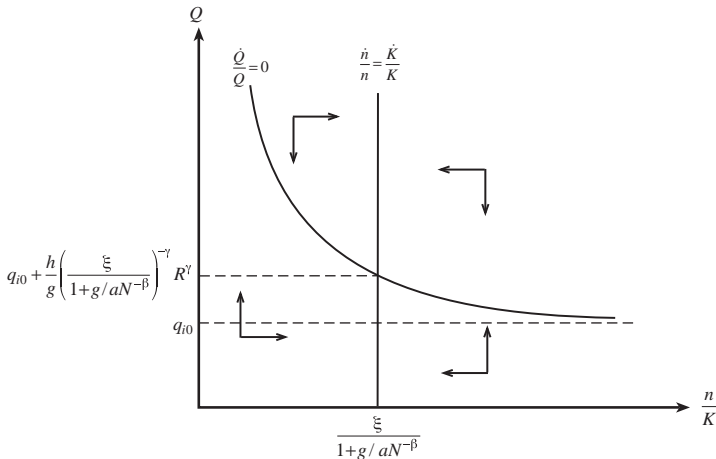
Fig. 1.2 Phase space of the dynamics in the model

above the steady state level for a given n/K, the marginal value of additional quality improvements is lower and R&D will fall, causing the growth rate of average quality to fall towards 0. The phase diagram clearly shows that the steady state is globally stable and unique. In that steady state, growth is driven entirely by the (exogenous) rate of knowledge accumulation.

1.3 Assessing the Contribution of Entrepreneurship to Growth

To assess the contribution of entrepreneurship to growth in our model, we set $q_{i0} = 0$ such that in equilibrium $N = 0$ and therefore (from equation (1.9)) $\dot{n} = 0$, hence no new product variety will be introduced in the economy. However, equation (1.17) still defines the steady state of the model. Also the demand for R&D is still given by equation (1.16). Given that now $\dot{n}/n = 0$, taking the time derivative of equation (1.16) and setting it to zero yield the following conditions for the steady state

$$\frac{\dot{E}}{E} = \frac{\dot{w}}{w} \tag{1.24a}$$

$$\gamma\left(\frac{\dot{K}}{K}\right) = \frac{\dot{Q}}{Q} \tag{1.24b}$$

Solving for the steady state level of R&D, we obtain

$$R^{SS} = \frac{n}{K}\left(\frac{\gamma g Q}{h}\right)^{1/\gamma} \tag{1.25}$$

which is a constant since K is assumed to grow at g and therefore (by equation (1.24b)), Q grows at $\gamma \cdot g$.[11] Again normalizing $E = 1$ we obtain

$$g'_U = \frac{1-\alpha}{\alpha}\gamma g \tag{1.26}$$

which is smaller than equation (1.20) by a factor γ, the output elasticity of the R&D industry. Hence the contribution of entrepreneurship to economic growth is

$$(1-\gamma)\frac{1-\alpha}{\alpha}g$$

which is always positive for $g > 0$ and $\gamma < 1$. Note that with $N = 0$, the mechanism of growth in the model has shifted from a variety expanding growth to a purely quality enhancing growth, however, both driven by exogenous knowledge accumulation. Our model will show a positive contribution of entrepreneurship whenever entrepreneurs add something qualitatively different to the process of innovations, as we have assumed. Moreover, we would argue that entrepreneurship is not only adding utility by introducing new goods and services but also enables

quality improvements by R&D by resetting the product life cycle and enabling the reallocation of R&D resources to products that are easier to improve.

1.4 Summary and Conclusions

While it is acknowledged in the literature that entrepreneurship plays an important role in the process of innovation, existing growth models do not explicitly consider this to be the entrepreneur's function. In this chapter, we model economic growth as a function of two distinct innovation processes, variety expansion, i.e. the introduction of new products, and quality enhancement of existing products. While the latter function is ascribed to an R&D sector that consists of existing firms, the first function is executed by entrepreneurs.

From a model building point of view, we show that it is possible to integrate both types of innovation process into a growth model. The model degenerates into a standard endogenous growth model with a quality ladder if entrepreneurs do not exist. On the other hand, the model degenerates to a standard model with variety expansion if the R&D sector does not exist. Therefore, our model can be considered as an exercise in bringing the entrepreneur into the mainstream models of economic growth. Several important extensions and refinements are feasible, desirable and required before entrepreneurship can take its rightful place at the core of growth models. We hope to contribute to that project with this chapter by outlining a possible basic modeling structure that is adapted from well-known models and allows for such extensions in further research.

With this model, we have shown that the economy converges to a stable non-trivial distribution among the three aggregates of the working population: labor, R&D employment and entrepreneurship. We can also show that this distribution leads to a stable non-trivial path of steady state growth of utility in the economy, provided the rate of knowledge accumulation is stable. We finally show formally that entrepreneurship does make a positive contribution to the process of growth of utility.

Based on these findings, it can be argued that scarcity of entrepreneurial talent and/or adequately trained R&D workers will slow down an economy. If, for some reason, entrepreneurial activity falls short of its steady state level, the level of R&D activity will actually be too high as the rate of variety expansion is below its steady state level, and this increases the value of quality improvement above the efficient level. On the other hand, a lack of R&D capacity will cause a lower rate of aggregate quality improvement, making entrepreneurial activity artificially attractive.

As the US and Europe can both access the same pool of knowledge, respective relative shortages of R&D capacity and entrepreneurial culture/spirit may explain the apparent specialization in entrepreneurial and corporate innovation, respectively. Finally, it can also be verified in the model that increasing ξ, (i.e. improving the permeability of the knowledge filter as conceptualized in Acs et al. (2003)) generates a one time increase in growth and raises the economy to a higher level of utility but not to a permanent increase in the growth rate.

Appendix

From [Equation (1.10) and (1.11)]

Entrepreneurs when introducing a new product to the market face uncertainty. In our model we have assumed symmetry among products in the utility function, which implies there is always a positive, actually infinite, demand for new varieties. Of course this is a simplification and uncertainty runs deeper than even our model allows. Yet a lot of uncertainty can still be introduced if required. We abstract from doing so to work out the fundamental properties of the model, but in no way would want to claim that our formalization of the entrepreneurial act captures this fundamental aspect of it. Having said that let us proceed. The reward for a successful entrepreneur is the flow of rents, monopoly profits, he can earn by bringing his new product variety to the market. Discounted to the present this flow of profits is given by the expression:

$$v_{n+1}(t) = \int_0^\infty e^{-r(\tau-t)} \pi_{n+1}(q_{n+1,0}, \tau) d\tau$$

By the assumed symmetry of goods and by assuming a known and given initial quality level for all new goods, this can be written as in equation (1.11):

$$v_n(t) = \int_0^\infty e^{-r(\tau-t)} \pi_i(q_{i0}, \tau) d\tau$$

Recall from equation (1.6) that profits, without further quality improving investments, are given by:

$$\pi_i(t) = \frac{(1-\alpha)E(t)q_i(t)}{n(t)Q(t)} = \frac{(1-\alpha)E(t)q_{i0}}{n(t)Q(t)}$$

Quality improvements are costly in our model so once in operation the decision to invest in them is a new and separate decision. The (discounted) additional profits of such investments will, in equilibrium, just offset the costs and therefore have no impact on the decision to bring the product to the market. Having said that, it is clear that the growth rate of profits equals:

$$\frac{\dot{\pi}_i(t)}{\pi_i(t)} = \frac{\dot{E}_i(t)}{E_i(t)} - \frac{\dot{n}_i(t)}{n_i(t)} - \frac{\dot{Q}_i(t)}{Q_i(t)}$$

which entrepreneurs with rational expectations know will be constant in the steady state. But if the growth rate is expected to be constant, (expected) profits at time t are given by:

$$\pi_i(q_{i0}, t) = e^{\left(\frac{\dot{E}_i(t)}{E_i(t)} - \frac{\dot{n}_i(t)}{n_i(t)} - \frac{\dot{Q}_i(t)}{Q_i(t)}\right)(t-t_0)} \pi_i(q_{i0}, t_0)$$

Dropping the time arguments on constant growth rates allows us to write the integral as:

$$v_n(t) = \int_0^\infty e^{-r(\tau-t)} e^{\left(\frac{\dot{E}}{E} - \frac{\dot{n}}{n} - \frac{\dot{Q}}{Q}\right)(\tau-t)} \pi_i(q_{i0}, \tau) d\tau$$

which solves easily into equation (1.11). Q.E.D.

Similar reasoning applies to equation (1.12), where the value of increasing quality is equal to the discounted marginal profit from higher quality.

Stability of the Steady State Allocation of Labor

The stability of the steady state can be shown by deriving the sign of the impact on entrepreneurial activity N and research and development R of increasing n and Q out of steady state equilibrium. The intuition is straightforward. If N exceeds its steady state level, the growth rate in n, by equation (1.10), is also higher than its steady state value. This implies that the economy will return to steady state only if a rise in n reduces the deviation from equilibrium entrepreneurial activity. Formally we check:

$$\frac{d(N(t) - N^{SS})}{dn(t)} < 0$$

Similarly for R&D:

$$\frac{d(R(t) - R^{SS})}{dQ(t)} < 0$$

If these conditions hold we know that production labor is also adjusting in the right direction and the steady state is stable. Substituting for $N(t)$ using equations (1.15) and (1.11) and for N^{SS} using equation (1.21) we find:

$$N(t) - N^{SS} = \left(\frac{w}{a\beta}\right)^{\frac{1}{\beta-1}} (\xi K - n)^{\frac{1}{1-\beta}} \left(\frac{(1-\alpha)Eq_{i0}}{nQ}\right)^{\frac{1}{1-\beta}} \left(r - \frac{\dot{E}}{E} + \frac{\dot{n}}{n} + \frac{\dot{Q}}{Q}\right)^{\frac{1}{\beta-1}}$$
$$- \left(\frac{R^\phi}{a} \frac{n}{\xi K - n}\right)^{\frac{1}{\beta}}$$

The derivative with respect to n is given by:

$$\frac{d(N(t) - N^{SS})}{dn} = \frac{\left(\frac{aEq_{i0}(1-\alpha)\beta(\xi K - n)}{n^2 Q\left(r - \frac{\dot{E}}{E} + \frac{\dot{n}}{n} + \frac{\dot{Q}}{Q}\right)w}\right)^{\frac{1}{1-\beta}} (n - 2\xi K)\beta + \left(\frac{R^\phi n}{a(\xi K - n)}\right)^{\frac{1}{\beta}} (\beta - 1)K\xi}{n(1-\beta)\beta(\xi K - n)}$$

of which the denominator is larger than 0, as well as the terms between large brackets in the numerator. It is then easily verified that the derivative is negative by the fact that $\beta < 1$ and $n - 2\xi K$ is also negative as $n^P = \xi K$ exceeds n. The number of

entrepreneurs will therefore return to the steady state level when the economy finds itself out of equilibrium. Q.E.D.

Similarly we can present the derivative of R&D employment with respect to average quality levels:

$$\frac{d(R(t) - R^{SS})}{dQ} = -\frac{n}{Q}\left(\left(\frac{R^\phi Q}{h}\right)^{\frac{1}{\gamma}} K\gamma + \frac{1}{1-\gamma}\left(\frac{EhK^\gamma(1-\alpha)\gamma}{n^2 Q\left(r - \frac{\dot{E}}{E} + \frac{\dot{n}}{n} + \frac{\dot{Q}}{Q}\right)w}\right)^{\frac{1}{1-\gamma}}\right)$$

Again it is easily verified that this expression is smaller than 0, which establishes the stability of the labor allocation in the steady state. Q.E.D.

Dynamic Properties of the Model

The dynamic properties of the model follow from the dynamics in average quality, Q, and variety, n, in and out of the steady state. Equation (1.6) states the *index of average quality* of all products in the economy

$$Q(t) \equiv \frac{1}{n(t)}\int_0^{n(t)} q_i(t)di$$

Deriving this index with respect to t yields

$$\frac{dQ(t)}{dt} = -\frac{\dot{n}(t)}{n(t)}Q(t) + \frac{\int_0^{n(t)} \dot{q}_i(t)di + q_{i0}\dot{n}(t)}{n(t)}$$

$$= (q_{i0} - Q)\frac{\dot{n}}{n} + \bar{\dot{q}}_i = 0 \quad \text{for} \quad \dot{q}_i = \bar{\dot{q}}_i \forall i = 1, 2, \ldots, n$$

Substituting in the R&D quality improvement function equation (1.7) we have:

$$h\left(\frac{n}{K}\right)^{-\gamma} R^\gamma = (Q - q_{i0})\frac{\dot{n}}{n}$$

Solving for Q and substituting g for the growth rate of n yields:

$$Q = q_{i0} + R^\gamma \frac{h}{g}\left(\frac{n}{K}\right)^{-\gamma}$$

It can be verified that $Q(t)$ will increase over time if $Q(t)$ lies below this line. Let

$$\dot{Q}(t) > 0$$

$$(q_{i0} - Q(t))\frac{\dot{n}(t)}{n(t)} + h\left(\frac{n(t)}{K(t)}\right)^{-\gamma} R^\gamma > 0$$

$$h\left(\frac{n(t)}{K(t)}\right)^{-\gamma}R^{\gamma} > (Q(t)-q_{i0})\frac{\dot{n}(t)}{n(t)}$$

$$\frac{h}{g}\left(\frac{n(t)}{K(t)}\right)^{-\gamma}R^{\gamma}+q_{i0} > Q(t)$$

Now consider the condition for n/K to be stable. Required is:

$$\dot{n}/n = \dot{K}/K = g$$

By the entrepreneurial production function (1.9) we know that:

$$\frac{\dot{n}(t)}{n(t)} = \frac{a(n^{P}(t)-n(t))N^{\beta}}{n(t)} = \frac{a(\xi K(t)-n(t))N^{\beta}}{n(t)} = \frac{a\xi K(t)N^{\beta}}{n(t)} - \frac{aN^{\beta}}{n(t)} = g$$

Solving for n/K yields:

$$\frac{n(t)}{K(t)} = \frac{\xi}{1+g/aN^{-\beta}}$$

If n/K exceeds this value, n will grow at a rate below g implying n/K will fall:

$$\frac{\dot{n}}{n} < g$$

$$\frac{a(\xi K-n)}{n}N^{\beta} < g$$

$$\frac{\xi K}{n} - 1 < g/aN^{-\beta}$$

$$\frac{\xi K}{n} < g/aN^{-\beta}+1$$

$$\frac{n}{K} > \frac{\xi}{g/aN^{-\beta}+1}$$

This implies the equilibrium in the graph depicted by Figure 1.2 is a stable attractor in the system. Arrows indicate the direction in which the system will move. Q.E.D.

Notes

[1]Smith (1776, paragraph I.6.5) acknowledged that entrepreneurs are the agents that affront the risk involved in developing new opportunities, stating that an "*undertaker*" is the one "*who hazards his stock in this adventure.*"

[2]Audretsch and Sanders (2007) illustrate how entrepreneurship is increasingly important as a source of competitive advantage by allowing an economy to switch to more innovative, more early stage production. In Audretsch (2007) it is argued that increasing global competition pushes formerly industrial "managed" economies towards an "entrepreneurial society."

[3]Scherer (1980) or CHI Research Inc. (2002). The U.S. Small Business Administration (1995, p. 114) enumerates some 70 important innovations by small firms in the 20th century, ranging from

low-tech innovations such as the Zipper or Bakelite to high-tech ones such as the nuclear magnetic resonance scanner or the microprocessor.

[4]Classic references include Romer (1986); Lucas (1988); Romer (1990); Grossman and Helpman (1991); Aghion and Howitt (1992). Jones (2005) provides an excellent overview.

[5]In the extreme case, these are technologies that are able to start up a new innovation life cycle in the sense of Gort and Klepper (1982).

[6]A standard time-separable utility function as in Barro and Sala-i-Martin (2004) yields the Ramsey optimal saving rate. We do not present the derivation here.

[7]See for example Grossman and Helpman (1991).

[8]In another version of the model, we endogenized g as a positive function of R in a specification à la Romer (1990). The outcome of the model is not affected by this specification. We therefore keep g exogenous for tractability.

[9]The results would not change if we would elaborate on uncertainty and risk. We could introduce heterogeneity in the population on risk aversion and endogenize the selection of agents over the occupations. We could work with risk premia in the discounting of future profit flows to reflect uncertainty or allow for non-rational and overoptimistic expectations on behalf of entrepreneurs etc. As our basic model structure would allow for such extensions we leave them for future research and choose to focus here on the entrepreneurial function as radical innovators.

[10]Here risk aversion would add a risk premium to the discount rate.

[11]Note that this implies that the growth of the model *without* entrepreneurship is entirely driven by quality improvement as opposed to the model *with* entrepreneurship, where growth is driven by variety expansion and quality improvement converges to zero (equation (1.19)). A constant rate of quality improvement can be sustained in this case as knowledge accumulation augments a fixed level of R&D employment. It is questionable that without the occasional introduction of new products, quality improvements can in fact be sustained ad infinitum. Under our current specification they can. The corner solution of our model where $N = 0$, however, yields a qualitatively different outcome.

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Chapter 2
Efficient Transfer of Public Scientific R&D to Private Firms

T. V. S. Ramamohan Rao

2.1 Introduction

The development and commercialization of modern technologies, especially biotechnology, has been knowledge intensive. No private firm has adequate scientific manpower or the laboratory tools to undertake fundamental activities in the early phases of development. Perforce they must be developed and incubated in specialized research institutions and transferred to private firms through appropriate organizational mechanisms. The dependence on such agents is also due to high costs of R&D and significant risks (both technological as well as appropriability) associated with such technological developments. These technologies are also such that a formal transfer of blueprints (or the disclosure at the patent filing stage) is generally inadequate to make efficient use of the results of R&D. The transfer of informal knowledge,[1] made possible only through close interaction with scientists, has become a compulsion.

One of the fundamental debates is about the role of the public sector in the context of biotechnology. Recall that the backbone of the Internet, that triggered the information technology revolution, was developed by public institutions and entirely financed by the U.S. government for its defense purposes. It had to achieve a certain maturity and depth of connectivity before it became commercially viable. But, in the biotechnology area, very few projects received similar public support primarily because such defense requirements were not discernible.

However, the progress of private R&D was hampered due to high costs and inadequate appropriability.[2] For, in the context of biotechnology, the uncertainties are significant, and the time lags between discovery and market returns are very large. As a result, private investment becomes viable only after a critical amount of government-sponsored activity materializes.

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This background, as well as several institutional and cultural considerations, necessitated a significant public sector involvement in India, Germany, Japan, and other countries. In particular, public policy was directed to the following activities (see, for instance, Wolf and Zilberman (1999), Giesecke (2000) and Lehrer, and Asakawa (2004)).

1. The government created and/or supported public institutions that undertake such research
2. Public R&D preceded private R&D in order to create the atmosphere for the latter to flourish[3]
3. Public institutions provided some concessions in finance to overcome the cost effect
4. Public policy nurtured venture capital and foreign direct investment
5. The government created a suitable patent and IPR regime[4]
6. Public institutions offered agricultural extension services to reduce costs
7. Public financing of national health schemes augmented the demand for medicines and their appropriability[5]

As Ramani (2002) pointed out, the above approaches to public policy focused on two ends of commercialization, viz., public research organizations and final product manufacturers. The effort was to retain the decision-making autonomy of each of the institutions involved, to the extent possible, and hope that formal interaction between them will develop to benefit society at large. This was also noted in Sharma (2000) and Raina (2003). However, as Ramani pointed out, "the indispensable intermediate link to (translate) scientific knowledge into technological competence was largely skipped".

The patent regime was an attempt to setup this link. The important development in the biotechnology sector was in the form of the Bayh-Dole act in the US and its impact on the government policies in other countries. Of fundamental importance is the grant of patents to knowledge developed by scientists in public institutions.[6] This enabled scientists in public institutions to recover the costs of R&D and appropriate the market value of their inventions either by creating startups on their own or license the use of their patents to private firms.[7] As Fischer and Byerlee (2001) pointed out, "many governments (are) asking public research organizations to recover part of their costs by commercializing their products and services including sales of research products (for example, sale of basic seeds), sales of non-research products and services (for example, soil tests), and various forms of joint ventures".

In sum, there has been an acknowledgement that in the context of the knowledge-intensive biotechnology industry, neither the public sector nor the private sector is in a position to undertake all the requisite components of the value chain entirely by themselves. As a result, cooperation in varying degrees is called for, depending on the organizational culture specific to a country and the industrial activity under consideration.[8]

The basic purpose of this study is to examine this nexus in biotechnology development. The primary objective is to emphasize the role of institutional mechanisms

in fostering entrepreneurship, realizing the potential value addition through commercialization, and the absorption of new innovations into the industrial structure in the steady state.

The rest of the chapter is organized as follows. Section 2.2 attempts to identify the nature of the institutional mechanisms for the transfer of informal knowledge. Section 2.3 notes that a particular policy option or a combination of policies may be efficient when the private firm experiences a specific difficulty. These will be identified using a principal agent model.[9] It will be acknowledged that the results of R&D, and entrepreneurship in general, can never be entirely deterministic. Perforce, there is an element of surprise in all R&D endeavors. In particular, it is well known that biotechnology developments may fail at the bioprocessing stage, regulatory level, or due to the lack of acceptance by the consumer of the final product of utility. Both the scientist and the private firm tend to keep their options open dynamically. Stated differently, a steady state cannot be predicted a priori and implemented exactly. The essential aspects of economic analysis consist in understanding the dynamics of adjustments and the factors that contribute to an eventual steady state, or prolonged disequilibrium. Section 2.4 concludes by summarizing the essential results of this study. It also points to a variety of issues for future research.

2.2 Institutional Arrangements[10]

There is a general acknowledgment that in the biotechnology area transfer of technology necessitates a variety of institutional arrangements.[11] Of particular importance are the following.

1. Transfer of blueprints and formal knowledge to enable the entrepreneur to create the expected product
2. Providing the physical materials, such as cell lines and laboratory tools for gene splicing, cloning, etc
3. Transferring the informal knowledge in the use of these materials and laboratory tools
4. The development, or acquisition by transfer, of the necessary equipment
5. Financial arrangements to support the production process[12]

There will be severe problems of coordination if many independent institutions take responsibility for each of these aspects.

Assume that a university scientist or a public sector institution discovered new knowledge that has commercial potential. The scientist may not be in a position to undertake commercialization due to the service conditions.

In the past, such knowledge, developed in the universities and public scientific institutions, was made available as a public good. Further, the transfer of blueprints and formal knowledge was adequate for private firms to pursue commercialization. However, private firms needed scientists who could understand the formal knowledge and convert it into manufactured products. In the initial phases, private

firms could not hire specialists because the educational institutions did not train an adequate number. Over time, this was undertaken as the technology gathered momentum. Hiring such trained hands was the primary institutional mechanism through which technology was diffused and used widely.

Even in the context of biotechnology developments the legalities of obtaining samples of microbes and animals were simple until about the 1980s. In many instances one could simply arrive at a field site, collect samples, and take them without bothering about legal issues. Samples could be transferred anywhere in the world. It is not possible in today's commercial world. The change in the patent regime created a climate in which even scientists in public institutions are encouraged to patent their knowledge discoveries.

One possible institutional mechanism to circumvent these problems is to allow the scientist to undertake commercialization at his own initiative.[13] This automatically provides the requisite informal knowledge but may not be efficient in so far as the comparative advantage of the scientist is in scientific discoveries, which may be slowed down if he becomes an entrepreneur.

A second approach to the problem is to allow a private firm, which is perhaps more competent in handling the commercialization stage, to pursue it. Several alternatives are available.

1. The scientist or the public sector institution transfers knowledge and allows the private firm to make all the decisions
2. They form a joint venture with both of them sharing costs and returns

In general, as Fischer and Byerlee (2001) remarked, "joint venture agreements are common for private-public collaboration. Each party contributes specific assets or knowledge, and shares benefits according to an a priori agreement. Since the application of many products of biotechnology requires incorporation into locally adapted germplasm, there are many opportunities for the public sector to enter joint ventures with the private sector, especially when serving emerging commercial markets of interest to the private sector." As Kalaitzandonakes (1999), Maria et al. (2002), Raina (2003), and Horsch and Montgomery (2004) pointed out, the ability to initiate and manage the dialogue between the public and private partners, towards clearly specified end products of potential economic and social value, is a valuable asset. Building it efficiently ultimately matters.

Setting aside the finer details it can be argued that the two basic institutional mechanisms available for the transfer of public scientific R&D to private firms are for the scientist to create a startup and become an entrepreneur or to license a private firm (or, totally sell off technology to it). There will be a necessity for specific institutional mechanisms for the transfer of informal knowledge if licensing turns out to be efficient.

Several alternatives have been utilized in different contexts. For example, over the years IISc encouraged its faculty to interact with industry and participate in the transfer of technology that they developed. More recently, both in Germany and India, scientists working in universities and research institutions have been permitted to work in industries for commercialization of their scientific discoveries. This

is in the form of a 3-year sabbatical from their parent organizations. At a somewhat different level, in India, micropropagation parks (for example, TERI in Delhi and NCL in Pune) have been utilized as intermediaries for the efficient transfer of technology to private firms. Generally the assistance provided relates to training and demonstration of technology for mass multiplication of horticulture and trees.

Such details are important in so far as they have implications for the costs of product development. Modeling exercises of the kind developed in this chapter will be generally insufficient to capture all such details. The attempt will be to capture the essential aspects in as much detail as possible.

2.3 Efficient Choices

The issue for analysis in this section relates to the choice of the most efficient set of organizational arrangements for the transfer of informal knowledge. In this context the most efficient refers to those that maximize net value.

Assume that a scientist from a public institution discovered scientific knowledge that is expected to have an eventual commercial value. Consider the case where n such product developments can be based on this knowledge.[14] Suppose, in the symmetric case, that each of the products is expected to generate a value m.[15] However, these developments have been subject to significant risk. The three major sources of such risk are

1. Risks of rejection by the regulators
2. Competition from non-GM varieties
3. Rejection by consumers[16]

It may be postulated that the actual value generated[17] is $(m + u)$ with u being a random variable with expected value[18] $E(u) = 0$, and variance[19] $V(u) = \sigma^2$.

The essential choice for the scientist is the fraction α of the number of products, n, that he prefers to develop on his own. It will be assumed that the development of the remaining $(1 - \alpha)n$ products will be licensed to private firms. Assume that production of each of the products entails a variable cost.[20] For the scientist it can be represented by $m^2/2\delta^*$. On the other hand, it will be assumed to be $m^2/2\delta$; $\delta > \delta^*$ for the private firm.[21]

Note that two different forces determine the variable costs of production. First, the level of output itself accounts for the variable costs. This can be captured by m^2. That is, it is postulated that there will be diminishing returns to the use of factors of production as m increases. Second, the scientist may not be as efficient as the private firm when it comes to commercialization. δ and δ^* therefore represent the degrees of efficiency of the scientist and the private firm. Postulate that the scientist or the private firm, as the case may be, incurs the entire cost.[22] The private firm can compensate the scientist, for providing patented knowledge as well as the transfer of informal knowledge, by offering a fraction p of the value generated from the sale of the product.

It is important to examine the role of the scientist in the case where a license is granted to a private firm. For all practical purposes, he has to

1. Offer informal knowledge in the use of technology
2. Monitor and control the private firm to guard against imitation and reengineering[23]

It can be expected that these costs will increase more than proportionately with m. Similarly, the costs will increase the farther the scientific invention is to the final product. This cost will therefore be represented by km^2. In general, k may be higher.[24]

1. The more the requirements of knowledge transfer
2. The farther away the invention is to a product of commercial value
3. The lower the IPR protection
4. The greater the costs of financing and/or financial constraints. No further attempt will be made to introduce the subtle differences in costs that each of these aspects imply[25]

The profit for the scientist can be written as

$$\pi_s = \alpha n(m+u) + p(1-\alpha)n(m+u) - \alpha nm^2/2\delta^* - (1-\alpha)nkm^2$$

It will be assumed, following the conventions of the principal-agent models of the Kawasaki and McMillan (1987) vintage, that the scientist is risk averse. Hence, the value he assigns to π_s will be

$$V_s = \alpha nm + p(1-\alpha)nm - \alpha nm^2/2\delta^* - (1-\alpha)nkm^2 - \lambda n^2[\alpha + p(1-\alpha)]^2\sigma^2$$

where λ is the degree of risk aversion of the scientist.

In a similar fashion, the profit of the $(1-\alpha)n$ private firms is given by

$$\pi_n = (1-p)(1-\alpha)n(m+u) - (1-\alpha)nm^2/2\delta$$

The private firms are also involved in many other production activities. Consequently, they can effectively diversify their risk. That is, they will be generally risk neutral. The value of the license to them will be

$$V_n = (1-p)(1-\alpha)nm - (1-\alpha)nm^2/2\delta$$

Contract theory generally supports assigning decisions to the party with better information. Hence, the natural choice of modeling is to leave the decision regarding m to the private firms. For, they have better market information. Clearly, the scientist is in the best position to choose α. Given that the scientist has a patent on knowledge, he can be expected to choose the terms of the license. In particular, he will choose the sharing fraction p as well. Each of the private firms derives a positive net profit as the number of product applications increases. Hence, they may not place any limit on n. But the scientist experiences diminishing returns with respect to increases in n. Consequently he will choose the efficient n as well.

Consider the efficient choice of m. It is given by $m = (1-p)\delta$. This represents the incentive constraint of each of the agents. That is, the private firm's output choice increases with its efficiency and the share of revenue it gets.

The principal-agent models generally postulate that the principal (in this case the scientist) maximizes the net value of the contract, viz., $N = V_s + V_n$, taking the participatory constraint of the agent into account.[26] That is, he maximizes

$$N = n(1-p)\delta - \alpha n(1-p)^2\delta^2/2\delta^* - (1-\alpha)nk(1-p)^2\delta^2$$
$$-(1-\alpha)n(1-p)^2\delta/2 - \pi n2[\alpha + p(1-\alpha)]^2\sigma^2$$

Each of the decisions of the scientist will be considered assuming the others as parametric. Adopting this approach identifies the transitional dynamics in an efficient manner.

Ceteris paribus, the choice of n satisfies the equation

$$(1-p)\delta - \alpha(1-p)^2/2\delta^* - (1-\alpha)k(1-p)^2\delta^2$$
$$-(1-\alpha)(1-p)^2\delta/2 - 2\lambda n[\alpha + p(1-\alpha)]^2\sigma^2 = 0$$

The following observations are pertinent.

1. $\partial n/\partial\delta^* > 0$. That is, an increase in the skill level of the scientist generates more startups including the licenses granted.
2. $\partial n/\partial k < 0$. An increase in the cost of monitoring and control by the scientist will deter him from granting more licenses. In particular, any reduction in IPR protection deters the scientist from entrepreneurship.
3. $\partial n/\partial\lambda\sigma^2 < 0$. A risk averse scientist is unlikely to grant too many licenses because that reduces his valuation of the expected returns.

Consider the choice of α, or the willingness of the scientist to create his own startup. The optimal choice of α is such that

$$-(1-p)\delta^2/2\delta^* + k(1-p)\delta^2 + (1-p)\delta/2 - 2\lambda\sigma^2 n[\alpha + p(1-\alpha)] = 0$$

The following results can be readily verified.

1. $\partial\alpha/\partial n < 0$. Clearly, the larger the number of possible applications the more he will contract out given his competencies for commercialization of technology.
2. $\partial\alpha/\partial\delta^* > 0$. That is, he keeps more applications to himself when he is more competent.
3. $\partial\alpha/\partial\delta < 0$ if $\delta > \delta^*$. Greater competence of the licensee relative to his own will obviously induce the scientist to contract out more often. It should also be noted that $\delta < \delta^*$ when the scientific knowledge is in early stages and requires extensive R&D before a marketable product emerges. In such a case the scientist will prefer to startup on his own.
4. $\partial\alpha/\partial k > 0$. That is, the more the monitoring and control necessary, and the more the requirement of informal knowledge transfer the more the scientist will prefer to create his own startup. The same applies when IPR protection is low.

5. $\partial\alpha/\partial\lambda\sigma^2 < 0$. Once again, it is plausible that a highly risk averse scientist will not invest in his own startups.
6. $\partial\alpha/\partial p < 0$. It is expected that the scientist will license out more often if his share of revenues increases.

It can also be inferred that the scientist will be the sole entrepreneur if δ is fairly large in comparison to $\lambda\sigma^2$ and n, and/or k is fairly large.[27]

Consider the issue of the relationship between the number of startups (including licenses) and the net value generated by the process of commercialization. Ceteris paribus, it can be verified that $\partial N/\partial\delta^* > 0$ and $\partial n/\partial\delta^* > 0$. Consequently, an increase in the competence of the scientist will improve N as n increases. However, it cannot generally be shown that $\partial N/\partial n > 0$ in all contexts. This is not surprising. For, entrepreneurial success in generating a higher value of N is contingent on the entrepreneurs being supported by the availability of capital, finances, and so on. It can be surmised that this result will hold even in the steady state. Hence, the entrepreneurship and growth nexus cannot be taken for granted.

2.4 In Retrospect

The present study was essentially an attempt to examine the factors that motivate the choice of a scientist in a public institution to start an enterprise, to commercialize the technology he developed, as against licensing it to a private firm to develop the product and market it.[28] The analysis suggests that the scientist in a public institution has a greater motivation to become an entrepreneur and create a startup if (a) the eventual expected value of the discovery is substantial, (b) patent protection for proprietary knowledge is inadequate, (c) there is extensive necessity for knowledge development before a product of utility to the consumer emerges, and/or (d) there is a significant involvement of the scientist in the transfer of informal knowledge to private firms. On their part, private firms will accept a licensing contract only if they have adequate expertise and/or low risk aversion. The institutional arrangements for financing biotechnology activity also tend to suggest that some form of joint venture will be the superior choice.[29]

Several extensions of the analysis suggest themselves. First, there are intrinsic uncertainties of commercializing innovative ideas. This implies that there will be short-term cyclical movements in the value generation process in the industry. Similarly, some ideas and innovations are far more fundamental. The risks involved will also increase correspondingly. The cyclical swings in the growth of the industry will then be deeper and also of a much longer duration. These empirical facts can be explained by suitable modifications of the principal-agent model adopted in this study. Second, the steady state solution of the model may offer further insights into the longer cycles and institutional arrangements to develop entrepreneurship. This will also provide deeper insights into the role of institutions in generating net value. Third, there is the issue of mergers and takeovers to create a consolidation in the industry after new startups and spinoffs are initially recorded. The steady state

solution may also provide some clues to explain this phenomenon. Fourth, a new technology such as biotechnology may not totally replace the more conventional non-GM technologies even in a steady state. This will clearly have an effect on entrepreneurial development in the biotechnology sector. The present model may be extended to offer some insights.

A more dynamic analysis of the technology transfer process, such as in Rao (2006), therefore appears more promising.

Notes

[1]Arora (1996, p. 235) puts it this way. "Transfer of chemical technology will typically involve training the licensee in a variety of issues such as how to handle and store chemicals, how to control the production process and return it to operation after (an) unscheduled breakdown caused by (an) accident or impurities in the feedstock." Such informal knowledge is necessary for better assimilation, utilization, and adaptation of technology. In the context of biotechnology it is also necessary to provide biological materials like cell lines. Further, it is necessary to train private firms in the use of laboratory tools for gene splicing, cloning, and so on. Informal knowledge refers to the demonstration by the scientist in the use of such biological materials and processes. It may turn out that the informal knowledge transfer requirement is purely transitory. Private firms may develop these skills on their own as the technologies mature. This was probably the case in the context of other technologies. Even so, this may be a much longer run requirement as the analysis of Arora suggests.

[2]The fragmented development of knowledge clearly depends on the competence of any one, or a group of individuals, in developing knowledge to a point where a product of commercial value emerges. The high costs may in fact be a result of this feature.

[3]Sonka and Pueppke (1999) noted that "much of the market application of biotechnology, in general, has involved small, entrepreneurial firms driving innovation. Often, these firms exploited publicly available knowledge to overcome their lack of (skill). Relative to agricultural technology, an important role of publicly supported research may be to create knowledge that can be used to fuel innovation in the market place."

[4]Several limitations of this approach have been recorded. One important aspect is that "patents and TRIPS agreement may exclude marginal farmers from benefits of biotech if all R&D and investment is private." See Chaturvedi (2002). Public sector activity is necessary to maintain a social welfare perspective.

[5]This was the major theme in Just and Hueth (1993).

[6]In the area of biotechnology patents for knowledge were considered essential to achieve widespread knowledge diffusion. However, it is now obvious that this was not achieved. Several alternatives are under consideration. See, for example, Rai and Eisenberg (2004), Rai (2005b), and Rai (2005a).

[7]Note that licensing technology is not a new concept in itself though it is now extended to public science as well. The issue of providing informal knowledge must be squarely addressed as a part of the licensing agreement.

[8]There is a general feeling that public scientific R&D will be relevant and amenable to commercialization if a private firm is allowed to make the choice of appropriate products (of use to consumers) and the public firm and its scientists develop technologies oriented to this goal. See, for instance, Raina (2003). Based on this philosophy, the Government of India used to stipulate that at least 30% government funded programs must have a commercial partner who will be responsible for directing R&D towards commercialization. Sonka and Pueppke (1999) also suggested that the private firm may be asked to finance a part of the R&D efforts of public institutions. However, as noted above, this results in political bias. Hence, many otherwise worthwhile scientific

developments may not be funded. In recognition of this limitation this institutional mechanism is generally not utilized. Instead, the process of development of scientific R&D is kept distinct from its commercialization.

[9]One good way of learning about the relative efficiency of policy options is to document the policies that various countries have been adopting and their relative success. However, this approach results in incremental thinking and offers suggestions for marginal adjustments in the existing public policy. It would be worthwhile to break free and attempt an analysis of the efficacy of more fundamental policy options.

[10]Three distinct organizational forms are discernible in the context of knowledge transfer in biotechnology industry.

1. Networks
2. Outsourcing
3. Open source architecture

Outsourcing is possible when the job can be divided into independent modules so that close collaboration is not needed. Open sourcing is a peculiar network when no specific product is targeted (it evolves over time without any premeditation) and there is no clear a priori knowledge about which set of hackers will be in a position to add value. Refer to Rai and Eisenberg (2004) for details. Clearly these approaches are feasible only if there is no necessity for intense interaction and acquisition of informal knowledge in the transfer of scientific information. It was, however, observed that informal knowledge is critically important for the assimilation of biotechnology knowledge. See, for example, Visalakshi and Sandhya (1997). Hence, the option of a public sector firm developing scientific R&D and formally offering it to a private firm is fraught with limitations. Networking and/or licensing a joint venture is by far the most efficient alternative in the context of the biotechnology industry.

[11]The coordination problems, between the scientists of a public institution and private firms, can be of three types. First, the development of knowledge is fragmentary and carried out by several scientists. These fragments of patented knowledge need to be coordinated to achieve a product of commercial value. For example, Byerlee and Fischer (2001) noted that enriched vitamin A rice (also known as the golden rice) is based on technology that spans 70 patents held by 31 different organizations. Private firms may feel inhibited while coordinating technology development with so many agents. Some centralized organizational mechanism may be more efficient. Second, a single aspect of knowledge developed may have many practical applications. The scientist may not be in a position to handle all of them if he becomes an entrepreneur. Hence, he may create some startups and license private firms to develop the others. Third, the context of creating germplasm and agricultural extension services appears to suggest that public sector institutions must be involved even at this stage. The basic problem here is that many recipients are involved and each of them needs specific help. In such cases the scientist, who initially discovered the technology, may not be in a position to handle the entire transfer process. Participation of public institutions may be more efficient. See, for instance, Gerpacio (2003). Detailed comparisons of several possible organizational arrangements were attempted in Berglund and Clarke (2000) and Fischer and Byerlee (2001).

[12]Even private firms may encounter financial constraints given the high risks of biotechnology projects. The Government of India (through its organ DBT) created BCIL (biotechnology consortium of India) with participation from IDBI, ICICI, and 30 other firms in the public sector. "It guided startups, arranged technology transfer and supported their efforts to attract adequate finances." For details see Ramani (2002). On the other hand, France allowed publicly supported scientists and institutions to become shareholders in the firms associated with their laboratories. They may, as a result of such arrangements, gain control on knowledge leaks and performance of private firms. When the financial constraint is a problem the scientist may also be allowed to seek venture capital and/or equity financing. However, this will reduce his control to some extent. It may also place a limit on the discoveries that can be moved to the commercial stage due to differences in perceptions about appropriability.

[13]It was initially difficult to entice the scientist in a public institution to undertake commercialization. For, university science is often

1. Directed to discovery and professional publication
2. Oriented to rewarding the scientists in the form of promotions, status, honors, and research funding
3. Supportive of free dissemination of information

Public science research is also constrained by the inability to

1. Obtain necessary finances from the government
2. Have access to private financial institutions
3. Break free from political patronage that determines the nature of research.

Fundamentally, these difficulties manifest themselves in the form of low motivation and ability of the scientists to create startups or high costs of doing so.

[14]There is a possibility that developing any one product depends on n different patented scientific inventions. The analysis is somewhat different in such a case. For details see Rao (2005).

[15]A private firm may also induce a public institution to undertake specific research that it will eventually implement. This has implications for the nature of the product choice as well as the method of financing fixed expenditures on R&D. This variant will not be pursued further.

[16]Appropriability of the expected value through the market process is an important issue. This will not be considered explicitly in this study.

[17]Input measures of R&D activity may be inadequate for a more detailed analysis. It is difficult to identify appropriate output measures and incorporate all the pertinent differences between technologies and products. Such a detailed analysis will be needed to define the efficient choice of instruments. However, such an analysis has hardly been initiated.

[18]The emphasis underlying this specification is that R&D and entrepreneurial activities are perforce subject to some element of surprise. Achieving unexpected success is as much a part of this process as failure. The alternative viewpoint is that no more than the targeted m can be achieved. In such a case the actual output m may materialize with only a probability q. Such an alternative modeling framework is available in Filson and Morales (2005).

[19]The sources of this variance are factors outside the purview of the decision making process of private firms. However, it will be argued in the sequel that it may be a result of the decisions of the joint venture partners.

[20]Inclusion of fixed cost, and, in particular, sharing between the joint venture partners, requires some major modifications in the model presented in this study. See, for example, Rao (2004) and Sharma and Rao (2006).

[21]The assumption that $\delta > \delta^*$ may not hold in situations where the knowledge being transferred is at the early stages, for the scientist may be more efficient in generating the fundamental knowledge necessary for the product development.

[22]The new technology may be embodied in the machine structure and the scientist may have to provide this to the private firm. In this case, the scientist has two options. He can provide the machinery and make the requisite investments. He then claims a royalty. Alternatively, the scientist may sell the equipment to the private firm. The scientist is generally reluctant to do this because patent rights are exhausted after such a first sale and this may result in reverse engineering by the private firm and eventual erosion of the advantage of the technological inventions of the scientist. The alternative, of the scientist incurring the costs of private firms, may be considered analogously. However, this appears unrealistic in practice.

[23]Low IPR protection may also make the scientist feel that the costs of licensing are higher.

[24]Note that the cost of licensing to a private firm is $km^2 + m2/2\delta$. On the other hand, if the scientist creates his own startup it will be $m^2/2\delta^*$. Hence, licensing will be feasible only if $\delta^* < \delta/(1+2k\delta)$.

[25]k will also decrease as more private firms acquire competence either through learning-by-doing or hiring young scientists who acquired the skills through training and education. k may also decrease as n increases and/or α tends to unity. It should be noted that a private firm may consider σ^2 to be high because they are not sure about the extent and/or efficiency of informal knowledge transfer that they receive. To an extent, therefore, σ^2 may decrease with an increase in k and/or α.

An efficient choice of k may also be conceptualized. Sharma and Rao (2005, 2006) contain some details of this alternative and its implications for the efficient transfer of technology.

[26]This corresponds to the spirit of the Coase theorem. That is, the principal-agent models posit that the issues pertaining to distribution of gains can be sorted out after achieving net value maximization.

[27]Similarly, the optimal choice of p will be such that $-\delta + \alpha(1-p)\delta^2/\delta^* + 2(1-\alpha)(1-p)k\delta^2 + (1-\alpha)(1-p)\delta n - 2\lambda n\sigma^2(1-\alpha)[\alpha + p(1-\alpha)] = 0$. Properties of the optimal choice of p can be explored as before.

[28]The analysis assumed complementarity between public and private R&D efforts towards commercialization. However, some studies emphasize the substitutability property of public vs. private R&D. Ishibashi and Matsumura (2005) and Alfranca and Huffman (2003) noted that in such situations public policies affect private firm R&D and its use. In particular, public funding of activity is inhibitive of private R&D because

1. Too much political patronage, and the associated intervention, curtails the freedom of the scientists to pursue their curiosities and hence the nature and scope of R&D
2. Too much public investment crowds out private initiative and investment. Appropriability of private investment decreases with the volume of public investment. For instance, why would a farmer pay for extension services if he gets them free?

However, modeling public-private interaction in the presence of substitutability requires a somewhat different conceptualization.

[29]The financial implications of this are also obvious. The private sector cannot continue making profits in the long run unless the finances provided by the government are paid back. The government should also accept the fact that the private firm will not produce goods of social value unless they recover costs adequately. Working out this delicate balance has been elusive for a long time and in the meantime any compromise solution can only be a second best. The present analysis suggests that the government must finance a greater share of the efforts of technology development and transfer whenever the above mentioned conditions hold.

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Chapter 3
Investing in Labor and Technology: Two "Faces" in India. Comparison of SMEs in West Bengal and Tamil Nadu

Meenakshi Rajeev

3.1 Introduction

There is no doubt that in any developing nation a planner interested in economic growth, in general, and industrial growth, in particular, needs to be concerned about the small-scale sector. In particular, in India, the sector's role is not limited to its contribution to GDP, export earning or employment generation alone. Extensions and adaptation of indigenous technologies, subject to the local availability of raw materials and labor, are features that enhance the importance of this sector. Further, low capital requirement makes entrepreneurship feasible for many. Given the importance of this sector for the Indian economy, it is useful to take a close look at some of the important statistics relating to this sector.[1]

The small-scale industries (SSI) sector in India creates the largest employment opportunities for the Indian populace (Figure 3.1), next only to agriculture.[2] It has been estimated that a lakh of rupees of investment in fixed assets in the small-scale sector generates employment for four persons.[3]

If we look at the state-wise distribution of employment in the SSI sector, Tamil Nadu (14.5%) made the maximum contribution to employment. This was followed by Maharashtra (9.7%), Uttar Pradesh (9.5%) and West Bengal (8.5%), the total share of the three states being 27.7%. We note that per unit employment however is not very high in West Bengal.

The small-scale industrial sector contributes 40% of the gross manufacture to the Indian economy. It has been estimated that a lakh of rupees of investment in fixed assets in the small-scale sector produces 4.62 lakh rupees worth of goods or services with an approximate value addition of 10%.

The small-scale sector in terms of number of units too has grown rapidly over the years Figure 3.2. The growth rates during the various plan periods have been

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e-mail: meenakshi@isec.ac.in
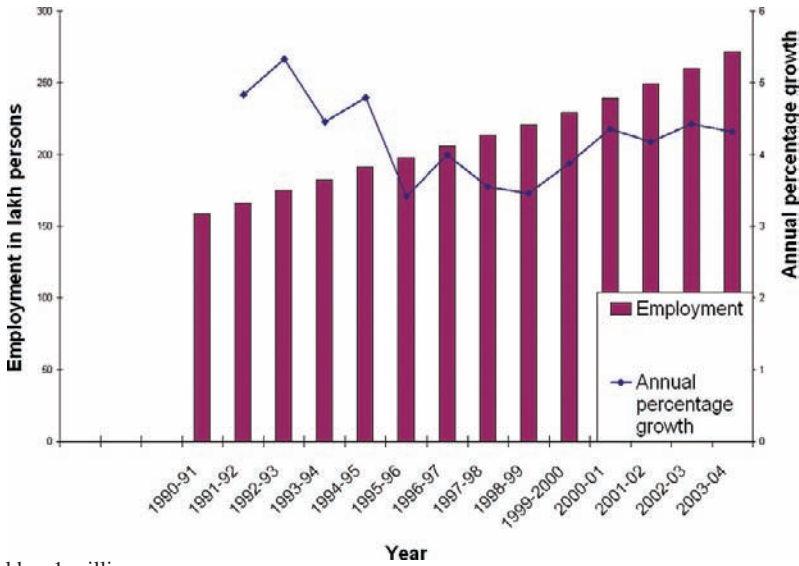
10 lakh = 1 million
Source: Annual Report, 2004–05, Ministry of Small-scale Industries, Government of India.

Fig. 3.1 Employment (in lakh persons) and percentage growth of employment in the SSI sector in India
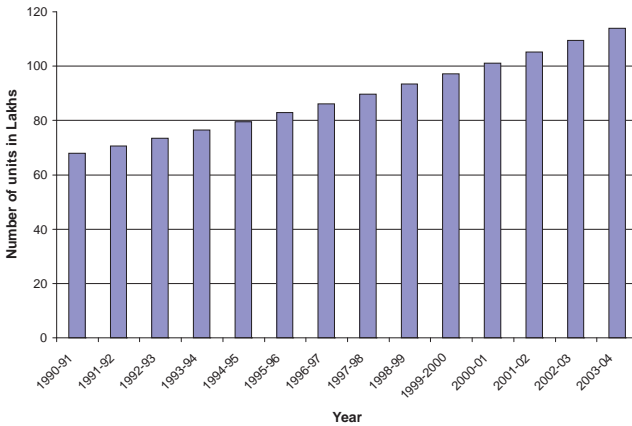
Source: Ministry of Small-scale Industries, Annual Report, 2004–05. Government of India.

Fig. 3.2 Total number of SSI units over the years in India (numbers in lakhs)

impressive. The number of small-scale units has increased from an estimated 8.74 lakh units in the year 1980–81 to an estimated 31.21 lakh units in the year 1999.

Furthermore, on comparison with the performance of the industrial sector in general and the manufacturing sector in particular, one observes that the SSI sector is

Table 3.1 Certain indicators relating to the SSI sector

Year	Fixed investment (Rs. Crore*)	(Rs. crore) Constant prices (1993–94)	Exports (Rs. crore)
1990–91	93555	68295	9664
1991–92	100351 (7.26)	79180 (15.94)	13883 (43.66)
1992–93	109623 (9.24)	93523 (18.11)	17784 (28.1)
1993–94	115795 (5.63)	98804 (5.65)	25307 (42.3)
1994–95	123790 (6.9)	109116 (10.44)	29068 (14.86)
1995–96	125750 (1.58)	121649 (11.49)	36470 (25.46)
1996–97	130560 (3.82)	135380 (11.29)	39248 (7.62)
1997–98	133242 (2.05)	147824 (9.19)	44442 (13.23)
1998–99	135482 (1.68)	159407 (7.84)	48979 (10.21)
1999–2000	139982 (3.32)	170709 (7.09)	54200 (10.66)
2000–01	147348 (5.26)	184428 (8.04)	69797 (28.78)
2001–02	154349 (4.75)	195613 (6.06)	71244 (2.07)
2002–03	162533 (5.3)	210636 (7.68)	86013 (20.73)
2003–04	170726 (5.04)	228730 (8.59)	NA

Figures in bracket represents growth rates.
* 1 crore = 10 million.
Source: Ministry of Small-scale Industries, Annual Report, 2004–05. Government of India.

not left behind. The growth of the SSI sector has surpassed overall industrial growth from 1991 onwards.

As far as its share in the export market is concerned, the SSI sector plays a major role by contributing around 45–50% of the Indian exports earnings (Annual Report, 2001–02 of the Ministry of Small-scale Industries). Direct exports from the SSI sector account for nearly 35% of total exports. Besides direct exports, it is estimated that small-scale industrial units contribute around 15% to exports indirectly. This takes place through merchant exporters, trading houses and export houses. They may also be in the form of export orders from large units or the production of parts and components for use in finished exportable goods. It is important to note that non-traditional products account for more than 95% of SSI exports (referred from www. smallindustriesindia.com). The sector in general has been exhibiting impressive growth rates in export performance during the 1990s (Table 3.1), the major contributors being the garment, leather, gems and jewelry units from this sector.

However, given the increased competition in the economy and the challenges of the WTO norms,[4] it is essential to take a fresh look at the policies concerning our small-scale sector. For example, if we consider the electronic instruments sector, small units are involved in two different categories of their manufacture viz., high-cost, low-volume products and low-cost, low-technology, high-volume products. According to the Small Industries Development Bank of India (SIDBI) report[5] most SSIs do not have the technical background or financial risk taking

ability to enter into high-tech field and rather like to slog in the low technology, highly competitive market and as a result are unable to improve productivity. Most SSIs still adopt 40 year-old technology and hence any sophisticated products have to be imported. Difficulty in adopting appropriate technology by the small firms is observed in many developing nations. Lack of information is a key problem affecting the SSE's access to technology in many developing nations including India and the African nations (Ogbu, 1995). Thus, unless appropriate policy measures are undertaken for the SSI sector, entry of competitors from other nations like China or Mexico has the potential to make the export scenario quite bleak for India.

While talking about policies[6] concerning this sector, it is essential to remember that there are innumerable sub-sectors within the SSI sector, producing a variety of goods in different regions of the country. Each such region has a distinct political and economic background and hence these units operate under differing institutional *structures*, which should not be undermined while formulating policies.

There is therefore a need to study these sub-sectors separately to arrive at a coherent picture of the structure of the small-scale industries (SSI) sector product-wise and location-wise. In fact, the SIDBI has brought out a report on 'Technology for small-scale industries, current states and emerging needs'. This document deals with important technology-related problems of small-scale industries for different product groups. However, the report does not concentrate on the *institutional framework* under which these firms operate. A study incorporating the institutional factors would enable one to take a fresh look at India's policies regarding the SSI sector, which are currently primarily characterized by '*subsidy and protection*.' The state of West Bengal in this connection provides some interesting and distinguishing features. In this regard, a paper by Benerjee et al. (2002), which deals with the economy of West Bengal in general, shows its concern about the poor condition of the SSI sector in West Bengal in spite of having all the necessary ingredients for growth.[7]

The present work is an attempt to study an important industry in the SSI sector of the state, viz. the *foundry industry*, in order to bring out the specific features that are region-based and examine the prospective policy instruments that may be necessary for its revival (see also Rajeev, 2003).

"One of the most labor-intensive industries, around 6000 foundries in the country, mostly in the SSI sector, produces nearly 3.3 million tons of castings annually (Hindu, Jan 25, 1999)." Though scattered across the country, the three biggest clusters of foundries are located in Agra in Uttar Pradesh, Howrah in West Bengal and Coimbatore in Tamil Nadu. As is well-known this industry is mainly engaged in iron casting produced by melting pig iron where hard coke is added as a fuel. Melted iron is poured into moulds of different shapes and sizes according to product specifications. Once the iron has solidified, it can be taken out of the moulds and processed further to get a better finish.

The industries at Howrah, which initially catered to the railway industry, made the region a flourishing industrial belt in the post-independence era with the foundry as one of its major components. In fact, it is said that the manhole covers on the roads of Paris were once all made at Howrah. Also the engineering units of the district,

engaged in different products, had backward linkages with the foundry industry. At present the district accommodates 152 foundries out of the 297 registered foundries in the state.

However, once the concentration of railway industries in West Bengal began to disperse to different parts of the country, almost the entire industrial belt at Howrah felt a major threat to their existence as a result of a drastic fall in local demand, compounded by the absence of product diversification as well as lack of search for alternative markets.

Of late, the condition of the foundry industry in particular is characterized by near-stagnation which the government officials associated with this industry (like the Director of the Indian Foundry Association or the General Manager of the Small Industries Development Bank of India, Kolkata Branch) attribute to the *risk averse and non-entrepreneurial* behavior on the part of the respective factory owners. An attempt to investigate further (methodology of the study is presented in the next section) into this perception led us to believe that it is to a large extent due to the manner in which industrial activities are organized in this belt. More precisely, our interactions with individuals associated with the foundry industry at different levels reveal that many entrepreneurs have reduced themselves to being just agents who are only renting out their capital goods rather than acting in the spirit of entrepreneurship. This has been the result of heavy dependence on outside intermediaries for supply orders and also for labor supply, which has created distortion in the firms' activities.[8] This is not to deny that there still exist some units in Howrah district which function in an impressive manner, but their proportion is rather small. To get a better comparative scenario we also visited several foundry firms in Coimbatore and interacted with individuals and organizations related to the foundry industry. In the Coimbatore district of Tamil Nadu there are 613 registered foundry units in operation (in the year 2000). The absence of a large intermediary network, unlike in the case of Howrah, has given rise to a different dynamism in the same industry located at Coimbatore. Capital investment in general appears to be much higher in Coimbatore vis-à-vis the industry at Howrah. Use of technologically advanced machines has brought about a marked difference in the final quality of products as well.

On the other hand our interviews with the foundry owners at Howrah reveal that they do not consider credit as a binding constraint, rather they believe that declining demand for their products acts as a primary bottleneck, which in turn has a dampening effect on the credit demand. However, if there is no credit constraint and, within the same country, Coimbatore entrepreneurs are finding investment profitable, why are the Howrah firms lagging behind? This question instigated us to explore the matter further.

The major problem in this entire study has been the availability of reliable quantitative data. The small foundry owners of Howrah were reluctant to provide any information relating to investment, production, cost and profit. This may be because they were not convinced of our academic intentions and were afraid of some additional tax liabilities. Absence of such data from any other sources forced us to depend on the experience we gathered through our visits and the qualitative information that has been revealed through interviews with various persons.[9] Our effort

in this paper therefore is limited to 'an exploration of a theory' (rather than an econometric analysis) based on information gathered from a series of open-ended interactive discussions carried out in a number of foundries, and related associations and organizations.

Against this backdrop the paper is arranged as follows. The next section describes the methodology of the study. This is followed by a description of the technology of production, since investment in technology is our main concern. A related issue that arises from the technology discussion is the pollution problem, which is taken up in the next section. We then move on to discuss the specific features of the Howrah foundry firms. The Coimbatore counterpart is taken up in the following section. A comparative analysis is presented thereafter and policy implications are discussed in the penultimate section. A concluding section appears at the end.

3.2 Approach to Information

Names and addresses of the registered foundries are available in published form, which we have used for selection of the samples. We have first selected a simple random sample of 30 foundries in Howrah out of the 152 foundries in the district (i.e. covering 20% of the units). Though we began with a structured questionnaire to be canvassed personally, as mentioned above, we could not get reliable figures from the Howrah foundry owners on several quantitative variables. This was then supplemented by an interactive investigation with unstructured open-ended questions. Thus the present paper is mainly based on 'selective, unstructured interactive (open-ended) investigations' and 'participant observations.'

In particular, we have interviewed the owners, accountants, laborers and the contractors associated with the firms. This gives us an idea about the institutional framework under which these firms function in addition to their basic structure, the process of production used, the sources of raw materials etc.

We visited the Indian Institute of Foundrymen, Kolkata Chapter and the Indian Foundry Association. The former provided us with much useful information regarding the present state and structure of the foundries, whereas the latter institution was completely uncooperative. Both these leading institutions also could not provide us with even a rough estimate of average turnover, profit, cost or total production of the industry at Howrah. In order to get a picture of the institutional credit, we have also visited the Small Industries Development Bank at Kolkata.

Names and addresses of the registered foundries are available in published form for Coimbatore also, which we used for selection of the samples from that region. We have first selected a simple random sample of 30 foundries out of 613 foundries in the district (i.e., covering 4% of the units). This representation may look inadequate; however, we could see a consistent pattern of operation through our visits and interactions. Though resource constraint prevented us to from undertaking a large-scale survey at Coimbatore, we would like to note here that the main focus of our study is to explain the characteristics of the Howrah firms. We have studied

the Coimbatore firms in order to strengthen our argument about the Howrah firms. The investigation procedure at Coimbatore was the same as that at Howrah. We visited the firms and carried out interactive unstructured investigation with different stake holders like the manager, owner and laborer to find out the product structure, labor management relation, technology upgradation etc. Information gathered thereby was supplemented by participant observations. We also interviewed the officials of the Indian Institute of Foundrymen, Coimbatore Chapter and Coimbatore District Small Industries Association. Interviews with private technical and marketing consultants were also illuminating. Chinese coke is used as fuel by most foundries in Coimbatore, which is a more efficient fuel, as its ash content is much lower than the coke produced in India. This being a feature specific to Coimbatore we also met the Chinese coke dealers.

3.3 The Technology of Production

The basic capital equipment used to produce cast iron is the furnace. The cupola furnace, which is the most widely used, is a cylindrical structure with a base. Alternating layers of hard coke (the fuel) and pig iron are arranged in the furnace, to which limestone and other ingredients are added to get a cleaner output. Iron that comes out in semi-liquid form through the side of the furnace is tapped by ladles and poured instantaneously into moulds for final casting. For each particular piece of casting a separate mould is necessary, which has to be placed firmly on the ground, and hence land requirement for iron-casting foundries is comparatively much higher than that for other SSI units.

Moulds are prepared mainly from sand and coal dust powder and are then dried for 4 h after which molted iron is poured into them. Sand is one of the few materials that can withstand such heat. As soon as the iron solidifies within the mould, it is removed from the moulds and the sand is cleaned from the surface.

Many of the sub-operations of this entire procedure can be carried out either manually or through machines. For example, mould-making machines can make moulds faster and with more precision. The sand-moulds can be machine dried to expedite the moulding operation. Completely mechanized systems can be used for preparing the sand for making moulds. Sand sieving, pouring into the moulds and baking are some such jobs. After removing the castings from the moulds shot-blasting machines can clean the product to give a noticeably smooth finish. A modern addition to this system of production is the *induction furnace* where instead of coke, electricity is used as the fuel. In this type of furnace, the mix of raw materials can be altered within the furnace until the desired level of precision has been reached. This is an added advantage, especially when one is concentrating on exports. From our visit to the foundries at Howrah and Coimbatore we observed that over 90% of the (smaller) foundries at Coimbatore have at least two such modern machines, which were completely absent at Howrah.

3.4 The Pollution Problem

The foundry industry is considered a highly polluting industry and labeled as a *red category* industry. As the furnace emits a lot of smoke and dust particles, which are atmosphere-polluting, strict norms have been stipulated of late regarding the height of the furnace. The norm depends on the circumference of the furnace. Depending on the circumference, many of the Howrah foundries had to spend 2–3 lakh of rupees for raising the height of the furnace. However, there was no help from the government to meet this sudden financial requirement. Many of the smaller foundries had to wind up their business for lack of funds to implement the norms of the pollution control board. Interestingly, however, at *both* Howrah and Coimbatore, the absence of appropriate credit facilities for implementing pollution control measures has been the common complaint of the entrepreneurs.

Furthermore, another problem faced by the foundries relates to the location of the firms. According to the pollution control norms, foundries cannot be situated near a residential area. In order to meet this requirement foundries have had to shift their location from time to time. Entrepreneurs of the Coimbatore foundries have shown strong disapproval for this norm. Their assertion is that foundries are initially set-up in non-residential areas. However, after the business is established, workers start residing nearby and slowly over time the neighbourhood becomes a residential area. As a result foundries are asked to shift out. But then the same process can repeat itself leading to the need to shift out again. Using this line of argument, Coimbatore foundries were fighting against this norm in court.

Pollution problems associated with the foundry industry however open up some additional opportunities for Indian foundries. The developed countries have been closing down this industry due their to strict pollution control norms, which in turn opens up the market for developing nations, where pollution control norms are not yet too stringent.

3.5 The Howrah Foundry Industry: Specific Features

The industrial cluster at Howrah is engaged in iron casting mainly through the cupola furnace where most of the units are engaged in low technology-based production viz., hand moulding or natural sand drying processes. Their main products vary from machine parts for sugarcane-juicers or flour-grinders to implements for the tea industry. Sanitary products like manhole covers are their specialty to the extent that this product was getting exported from Howrah to various other parts of the globe, including Europe.

Though the production process at Howrah is highly labor intensive, a large proportion of the small-scale units have a single employed laborer. Surprisingly, they manage the entire production using contract laborer. To begin with however these industrial units did have permanent workers with numbers varying from 10 to 20. This structure has gone through some drastic changes since the 1980s (see

Table 3.2 Man-days lost due to lock-outs in the industrial sector

States	1985	1990	1992
Andhra Pradesh	646	299	1500
Bihar	186	130	364
Delhi	21	132	–
Gujrat	379	316	227
Haryana	4	14	960
Karnataka	631	20	0
Kerala	253	194	411
Madhya Pradesh	640	5	0
Maharastra	2868	4429	2803
Orissa	21	6	176
Punjab	41	41	54
Rajasthan	220	52	122
Tamil Nadu	908	671	843
Uttar Pradesh	107	526	533
West Bengal	10769	6592	7990

Source: Economic Intelligence Service, India's Industrial Sector, January, 1996.

Table 3.2). During this period, 90% of the units under survey underwent lockouts preceded by labor strikes. This period also coincided with the fall in demand for foundry products from the railway industry. Around 90% of the *smaller* units we have surveyed in Howrah now have no permanent employees save the watchman and the accountant. All employees are contract laborers who work under a contractor, and the latter, in addition to supplying labor to the foundries, also brings orders for their products from different firms (which have backward linkages with foundries) located in Kolkata (the nearby metropolitan city), Howrah and the neighboring areas. The same intermediary (contractor) also supervises the work and makes payments to the labor. When casting is over, he pays the entrepreneur at the rate of Rs. 13 per kg of the finished product, which in turn he supplies to the respective nodes at a higher price.

The role of the so-called entrepreneur is to supply the raw materials and provide capital services (e.g. the furnace and the land). Thus he appears to be more of a person who is renting out his capital and land rather than acting in the spirit of an entrepreneur.

3.5.1 The Intermediary Setup at Howrah

Our interviews with the contractor/intermediary class reveal that a large proportion of them were previously engaged as workers in this industry and later took on the role of intermediaries. Thus one can *hypothesize* that demand uncertainty and labor unrest created an uncertain situation for the foundries. This in turn led the entrepreneurs to prefer a non-permanent employment structure whereby they needed to pay the laborers only when there was work. Further the labor management problem would no longer be their headache. Consequently, in response to this

demand, there arose an intermediary class, a subset of the original set of labor-
ers, who were intelligent enough to acquire the necessary information regarding the
local sources of demand for the foundry products and had the ability to manage the
laborers. The remaining laborers now work under these intermediaries on a daily
wage basis. The intermediaries are not necessarily former union leaders.

The interesting point here is that 10–12 laborers are attached to an intermediary
almost on a permanent basis. The intermediaries not only pay wages but also provide
other employment benefits like accident benefits, festival bonus etc. This indicates
that there exists a long-term relation between the laborer and the contractor. Since
no capital is required to be an intermediary, there are a sizeable number of them
operating in the market, and as a result *competition prevails* between them not only
with regard to obtaining orders for foundry products but also for attracting more
efficient laborers through better wages. (Usually the wage ranges from Rs. 40 to Rs.
50). Thus an *intermediary operates in a competitive market*.

The intermediary class is widely prevalent in the small-scale and informal sec-
tor of West Bengal, and usually takes the form of subcontracting. In the case of
the foundry industry, on the other hand, the firm owners neither subcontract nor
produce on their own. The production operation is managed and carried out by the
intermediary in the factory premises of the owner. Thus, in a sense the intermediary
is playing the role of an entrepreneur with the important deviation in that s/he has
no control over investment (see Coase, 1937). S/he is basically leasing capital and
coordinating between different factors of production.

3.6 The Coimbatore Counterpart

3.6.1 Coimbatore District: A Profile

A quiet agricultural town, until a few decades ago, Coimbatore today has a rich
entrepreneurial culture. The soil in this district consists predominantly of black soil,
and it is more suited for the production of cotton. Under the British rule, cotton was
exported to the textile mills in England, and due to the great demand for raw cotton,
farmers found it profitable to engage in the production of this cash crop. The British
set up the first textile mill in Coimbatore in 1888. The local entrepreneurs realized
the commercial potential in setting up textile mills rather than supplying raw cotton.
The first mill set up by a local entrepreneur was in 1907, and thereafter Coimbatore
has witnessed a steady growth of textile mills ranging from small and medium to
large units.[10]

The textile machinery industry in Coimbatore produces over 80% of the spinning
machinery (from bowl room to ring frames and rotors) produced in the country. The
quality of the machinery is quite satisfactory, and, besides catering to the domestic
market, is also exported to various developing countries. In addition Coimbatore
also manufactures automatic weaving machines and high-speed circular knotting
machines.

With the commissioning of the Pykara Hydro Electric project in 1929, sufficient power was made available in Coimbatore. With this began the evolution of the pump industry, for which Coimbatore today is well-known. Today the engineering industry is producing a wide range of products like monoblocks, electric motors, domestic pump sets, submersible pump sets and deep well compressor pumps. The quality, reliability and performance of these pumps have earned a reputation for the industry and they are being exported for the last three decades. Today Coimbatore produces more than 40% of the country's requirement of motor-pump sets. Over 350 units manufacture electric motors (suitable both for industrial and agricultural purposes), and irrigation pumps (including submersible and compressor pumps), which are marketed both in India and abroad.[11]

With the emergence of these industries, especially the development of the pump industry, a number of foundries have been established in Coimbatore. These provided the necessary base for the light-engineering entrepreneurs of Coimbatore to diversify and venture into indigenization of the machinery and spares needed by their diverse manufacturing activities. In fact, over 500 foundries manufacture steel castings, ferrous castings, gray iron castings and alloy steel castings. Apart from the substantial industrial base, which in particular created a favorable atmosphere for the foundry industry, another aspect that has helped in its development is the existence of people with technical know-how. There are quite a number of technical institutions in the district, nine engineering colleges, seven polytechnics and three industrial training centres. Interestingly, our survey shows that rather than looking for white collar jobs, many of the technical people have set up their own industries, after gaining some preliminary experience. This has helped to organize research activities and develop indigenous technologies.

3.6.2 Organizations for Research and Technology Upgradation

The two major institutions that play crucial roles for the industry in the region are the Institute of Indian Foundrymen (IIF), Coimbatore Chapter and Coimbatore District Small Industries Association (CODISSIA). While the IIF provides with technical assistance, the latter institution gives relevant information about government norms and regulations. It organizes training programmes for small and large entrepreneurs and furnishes information regarding marketing facilities and export possibilities. Both these institutions play a non-trivial role for the upliftment of the foundry industry of the district.

Apart from these two organizations, two other research associations also play an indirect but crucial role in technological upgradation of the products. As mentioned earlier, foundries are necessary for casting different parts of the machinery used by other industries. Therefore, an improvement in the technology of an industry like textile machinery or motor and pump industry, has a direct effect on foundries. In this regard, one may mention that the South India Textile Research Association which offers services to the textile industry in constantly upgrading information on

technology. Also, the Small Industries Training and Research Center helps the motor and pump industry in quality and technology upgradation and consumer education. These in turn have an effect on the need for improvement of products of the foundry industry.

In addition to the technical competence, the entrepreneurial class in general has created a completely different attitude towards business for these foundry owners located in Coimbatore. For example, the Gandhi Kumar foundry, which is comparatively a much smaller foundry, whose owner is an engineering graduate, has been able to develop some castings for the pump industry, which promises more efficient functioning of the final machines. In particular, his castings are reported to help in lifting water from a deeper level at a higher speed. This is not the sole example of such innovative endeavors.

Non-dependence on any intermediary has forced the entrepreneurs to look out for markets on their own. This has enabled them to know better the market conditions, new technologies and potentially profitable investment possibilities. Apart from these, quite a few competent marketing and technical consultants are involved in market surveys and research about new technologies, and work with comparatively bigger foundries on a contract basis. Our interview shows that some of these consultants even offer their services to developed countries like France.

Howrah district on the other hand lacks such research and developmental endeavors. Further, poor infrastructure adds to poor industrial growth in the state. In 1980–81 West Bengal produced 9.8% of the industrial output of the country. During 1995–96 it declined to as low a value as 4.7%, while the overall industrial growth of the country was satisfactory. As far as infrastructure development is concerned, according to a recent study, West Bengal's position is as low as 14th amongst the Indian states in terms of an index for infrastructure (Benerjee et al., 2002).[12]

3.6.3 The Major Difference

Even though there are a number of aspects on which the industry in these two locations differ, the major difference that strikes one in the Coimbatore industrial belt is the absence of the intermediary class. There are indeed some labor contractors who supply laborers on contract. This is mainly due to the fact that in a foundry, labor requirement is high only on days when melts are undertaken and melts usually take place twice a week. On other days, the foundry is involved in mould making, cleaning of castings or in sand preparation. Ten to twelve laborers are sufficient for this job in a small foundry. It is therefore optimal to hire the extra 10–12 laborers on a contract basis on the days when one is operating the furnace, which as mentioned earlier, is usually twice a week. However, the labor contractors are never allowed to play a dominant role in the production process. This has naturally made considerable difference to the functioning of these factories vis-à-vis their Howrah counterparts. Other differences we observe appear to be a result of this phenomenon.

From the above discussion we get an indication that the labor problem has led the Howrah firms to opt for an intermediary network that supplies entire labor force on a contract basis. Below, we look at this problem little more rigorously in a game-theoretic framework to understand why it is optimal for the Howrah firms to do so, and such a strategy is not optimal for the Coimbatore firms. This has been explained on the basis of the possible threat of labor strike and the resulting problem of lockout faced by the Howrah firms, which can be overcome by using an intermediary. The important question that why laborers do not strike under an intermediary has been addressed as well.

3.7 Labor-Entrepreneur Relationship: A Game-Theoretic Representation

Here we try to represent the observed labor-management relation through a simple game-theoretic model with two decision-making entities (see also Rajeev, 2004):

1. Labor
2. Management (may be a firm owner or an intermediary)

Based on the situation that prevailed (as revealed from our survey), we consider two strategies for the labor, either to go for a **strike (S)** or, alternatively, **not to do so (NS)**. The management in such a case can **continue (C)** production possibly through negotiation or decide to **lock out (LO)** the firm. Outcome of a strike can be a raise in wage to a level w_H from the existing level $w_L(< w_H)$. However, chances of success for the labor to be able to raise the wage is assumed to be $q(P)$ a function of the power of the labor union $'P'$. If the union is successful in raising the wage to w_H, then discounted lifetime earnings for a labor becomes

$$w_H(1+\rho+\rho^2+\rho^3+\dots) = \frac{w_H}{(1-\rho)} = W_H, \qquad (3.1)$$

where, ρ is the discount factor. Similarly corresponding (lifetime) discounted value for w_L is denoted by W_L. Thus, in this setup, expected discounted lifetime earnings of labor is

$$qW_H + (1-q)W_L - d(e), \qquad (3.2)$$

where $d(e)$ is the disutility from the effort e that is needed for engaging in a strike, which is assumed to be positive for $e > 0$. If $d(e)$ is sufficiently high such that $(2) < 0$, then we arrive at the trivial solution of having no strike. Therefore, we consider the situation where $d(e)$ is not too high; in particular, we assume that $d(e) < W_H - WL$. Suppose, for the firm owner, profits associated with the higher and lower levels of wage rate are L and H respectively (higher wage rate leads to lower profit etc.). As

defined earlier, a profit earner's discounted life time pay-off is

$$\Pi_i = \pi_i(1 + \rho + \rho^2 + \rho^3 + \ldots) = \frac{\pi_i}{(1-\rho)}, \ i = L, H. \tag{3.3}$$

In the given setup, a firm owner may decide to continue production or opt for lock out. If s/he decides to continue production ex-ante, his/her expected profit would be $q\Pi_L + (1-q)\Pi_H$. Clearly, if the laborers do not engage in a strike, they continue to earn w_L. While considering the possibility of a 'lockout,' we examine case of a firm owner and an intermediary separately.

Case 1: Firm owner taking into account the possibility of a lockout

We assume that a lock out of the factory will have the following cost-benefit implications for the firm owner.

1. He/she may have to pay a lump-sum amount $W(>0)$ (as a compensatory benefit) to the workers. This possibility is dependent on P, and the probability that s/he may have to pay a compensatory benefit is $q(P)$.[13] For the labor $W > d(e)$, otherwise we arrive at a trivial solution.
2. S/he needs to forgo rental r on the fixed capital up to t periods.
3. After t periods, s/he will be able to sell the fixed capital, and new investment will take place, which would yield an expected return per period.

   Thus, expected life time earning of a firm owner in the event of a lockout is

$$-qW - (1 + \rho + \rho^2 + \rho^3 + \ldots + \rho^t)r + (\rho^{t+1} + \rho^{t+2} + \ldots) = -qW - R + \Pi$$

with $R = r(1 - \rho^{t+1})/(1-\rho)$ and $\Pi = \rho^{t+1}/(1-\rho)$.
The laborer in turn earns $qW - d(e)$.
If lock out takes place in the absence of a strike, $W = 0$.

The various possibilities are depicted through the pay-off matrix below:

		Labor	
		S	NS
Management (firm owner)	C	$q\Pi_L + (1-q)\Pi_H,$ $qW_H + (1-q)W_L d(e)$	Π_H, W_L
	LO	$-qW - R + \Pi, qWd(e)$	$-qW - R + \Pi, 0$

Given this structure, depending on the value of labor power P and the resulting $q(P)$, different outcomes might result as mentioned in Proposition 1 and 2 below.[14]

Proposition 1: If $q(P)$ is high, in particular $q(P) \to 1$, then under Case 1, (C, S) and (LO, S) are two possible Nash Equilibria.

Proposition 2: If $q(P)$ is sufficiently small, in particular, $q(P) \to 0$, then (C, NS) and (LO, NS) are the possible NE (under Case 1).

Note 1: Proposition 1 indeed corroborates to the existing scenario at Howrah where, labor union power P and the resulting $q(P)$ are rather high. More than 90% of the factories we have surveyed faced labor strikes and after that a sizeable proportion of firms have changed hands. Proposition 2 on the other hand resembles the situation in Coimbatore. As far as the labor is concerned our field study shows 0% labor strike. Furthermore, we have observed that more than 50% of the firms at Howrah have gone to new entrepreneurs after the labor unrest, which is not the case in Coimbatore.

Case 2: An intermediary facing the possibility of lockout

When an intermediary is managing the labor and the production process, given the fact that s/he operates in a competitive market, s/he is assumed to earn only normal profit which is denoted by π (life time pay-off is Π, say).[15] Thus once s/he decides to stop her/his operation, s/he is assumed to earn same return from a similar alternative occupation with a minimal search cost s. Given the fact that the intermediary has no fixed capital locked up in the business, we assume that $W = 0$ in an intermediary set-up. The following pay-off matrix shows the pay-off of the intermediary under two strategies (C and LO) for different values of q.

		Labor	
		S	NS
Intermediary	C	$q\Pi_L + (1-q)\Pi, qW_H + (1-q)W_L - d(e)$	Π, W_L
	LO	$\Pi - s, d(e)$	$\Pi - s, 0$

The Figure 3.3 below represents the pay-offs for the intermediary and labor for different values of q.

Here, in the horizontal axis we are measuring q, and in the vertical axis the pay-offs. The double lines are relevant for the intermediary. The horizontal double line (starting at $(0, \pi/(1-\rho))$) shows the lock-out pay-off for different values of q, and the slanting double line (starting at $(0, (\pi/(1-\rho)) - s)$ with slope $(\pi/(1-\rho) - \pi_L/(1-\rho))$ shows the pay-offs in case of continuation (C), if there is a strike. These two lines intersect at $q = q^*$, say. The broken lines are relevant for the labor. The horizontal broken line shows the NS pay-off in case of continuation of production. The broken line with a positive slope shows pay-offs under S for different values of q, if production continues. These two lines intersect at $q = q_L$, say. Using this diagram and the above pay-off matrix one can infer that:

Proposition 3: Under Case 2, (C, NS) is the unique pure strategy Nash equilibrium if $0 \leq q \leq q_L$ and no (pure strategy) equilibrium exists otherwise.[16]

Note 2: This case also explains why we do not observe any labor unrest under an intermediary, and the major reason behind evolution of such a network.

Thus, we observe through the above formulation the advantage of having an intermediary network for the Howrah firms. However, such an arrangement has far reaching implications that we discuss below.
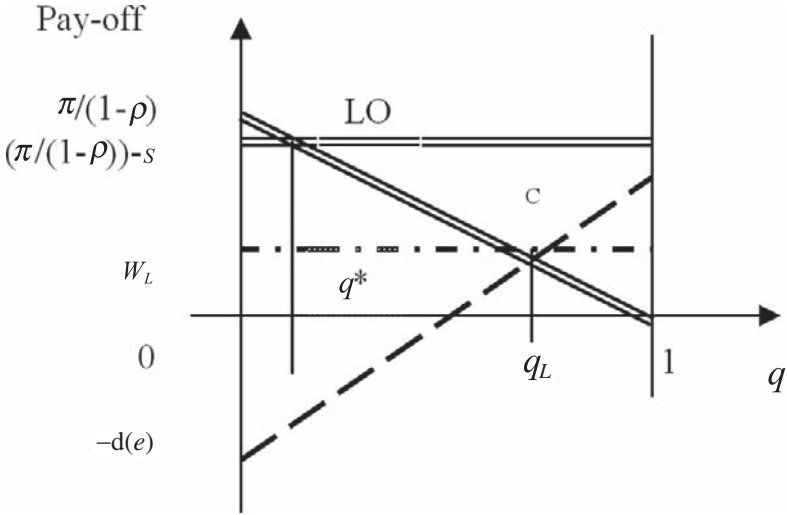
Fig. 3.3 Pay-offs for the intermediary and labor

3.8 A Comparative Analysis

Labor movements leading sometimes to lockouts gave rise to a system of contract labor in the factories. The new system was a welcome relief for entrepreneurs, as they are obliged to pay the laborers only when there was work. Also the labor-management dispute is no longer their problem. As the system grew popular, a reasonable number of contractors entered this business, since there is no capital requirement for being an intermediary. Contractors are in a more advantageous position to deal with the labor as their *fixed capital is not locked up* in case of any labor movement. Since the laborers are aware of this fact strikes and lockouts are absent in this system of operation.

As these exogenous contractors or intermediaries now have complete hold over an important factor of production, viz. labor, they are in a better bargaining position. After the industrial unrest, many of the original entrepreneurs chose to leave the business. In the process, many of these firms changed hands. The new owners naturally had less experience in this business. Given this background, it was a welcome situation for the entrepreneurs when these contractors also volunteered to bring in orders for manufacture and manage the hassles of payment.

However, this style of operation has some economic implications. One needs to raise the question here, "whether these foundry units really represent firms?" The coherent and consistent concept of a firm as a nucleus of coordination of different factors of production is actually in the hands of the middlemen here, and they are not the owners of the firm. The entrepreneur in whose name the firm is registered has no involvement in the actual production activity, nor does s/he bear the risk of *fluctuating, residual* income (Knight, 1921). On the other hand, though s/he manages the firm, the intermediary cannot make any investment decisions.

Given this background, though the prevailing arrangement appears to be advantageous to the entrepreneurs, it has its far-reaching effects in the long run. First, this process of operation has reduced the actual entrepreneur (who is supposed to be the decision maker for new investment) to a person who is basically renting out his capital equipment. A natural consequence of this non-involvement is a dampening effect on his *expectations* regarding profits or turnovers from the business. This has resulted in the *non-entrepreneurial attitude* of the actual owner having an adverse effect on the entire industry.

Second, this alienation from the actual production activity has widened the information gap for entrepreneurs, especially regarding market conditions. They do not know to which market their products are bound, whether there exists a potential demand, provided they can modify their product quality or the productivity. As a result, in the face of any demand crunch, a natural way out for a large proportion of them is to close down the unit rather than look for other opportunities, which is beyond the purview of the existing intermediaries.[17] The *information gap* so created by their alienation over time has made the expected search cost high enough vis-à-vis their *expected gain*. Thus, while due to certain historical reasons the firm owners have started with a particular arrangement, in the long run such arrangements have hampered the growth of their own business, restricting the firms to a low level equilibrium. To visualize the problem clearly, below, we represent the situation using a couple of diagrams on the basis of a simple search model.

3.9 Search Cost and Optimal Behavior: A Theoretical Formulation

One way of formalizing entrepreneurial behavior discussed so far is to use the tools of agency theory (see Eisenhardt, 1988; Smith and Jensen, 2000). Agency theory is concerned with the moral hazard and other problems faced in a principal-agent framework. We try here to emphasize more on search cost in modeling the entrepreneurial behavior.

Let us now try to represent the situation that prevailed in the two locations in terms of simple diagrams. We assume that each entrepreneur can search markets to sell their products. There is a search cost (transaction cost) which we represent by $d(e)$ as disutility from putting an effort e to search, $0 < e < 1$. With probability p one can get a new order from a search that would increase the income of the entrepreneur by I.[18] In the absence of a search, an entrepreneur may earn a fixed income $\bar{I}$ through the intermediary network. The probability $p = p(\bar{i}, e)$, where, $\bar{i}$ is the level of information available in the location, $0 < \bar{i} < 1$. For example, if many buyers already exist in the local market, there is presumably more information flow and hence with the same effort e, there is comparatively a higher chance of getting a new order, and hence an increase in income by I. We make the following reasonable assumptions about p and d.

$p(\bar{\imath}, e) \geq 0$, $p(\bar{\imath}, e) = 0$ if $e = 0$, $d(e) > 0$ if $e > 0$ and $d(e) = 0$ if $e = 0$, $d'(e) > 0$, $d'' < 0$. In particular, the following form of the p function may be assumed given $0 < \alpha < 1$:

$$
\begin{aligned}
p(\bar{\imath}, e) &= \bar{\imath}^{\alpha} e^{1-\alpha}, \text{ if } \bar{\imath} > \varepsilon \\
&= 0, \text{ if } 0 \leq \bar{\imath} \leq \varepsilon \text{ and } e \leq e_0 \\
&= \varepsilon^{\alpha} e^{1-\alpha}, \text{ if } 0 \leq \bar{\imath} \leq \varepsilon \text{ and } e > e_0,
\end{aligned}
$$

where ε and e_0 are small real numbers (less than unity). Thus this probability function assumes that if the initial level of information is quite low and the search effort is also not high, then the chances of finding additional marketing opportunities are nil. However, if the initial effort level is higher (than say, e_0), then even with less information to begin with one may find additional marketing opportunity with probability $\varepsilon^{\alpha} e^{1-\alpha}$. But if the initial information level is higher, then probability is an increasing function of effort e and information level, and is given by $\bar{\imath}^{\alpha} e^{1-\alpha}$.

Let $U(I)$ be the utility derived from an income I. If $I = 0$, $U = 0$.

Case 1: Howrah

Given the above assumptions, the expected utility for a Howrah entrepreneur from putting in an effort e to search for a new market is

$$
\hat{U} = p(\bar{\imath}, e) U(I + \bar{I}) + (1 - p(\bar{\imath}, e)) U(\bar{I}) - d(e).
$$

If he does not put in any effort, his utility would be $U(\bar{I})$. It can be easily checked that $\hat{U}$ is concave.

Proposition 4: If initial $\bar{\imath}$ is sufficiently small, in particular $\bar{\imath} \to 0$, then $e = 0$ is the optimal solution for an owner.

Proof: Since w.r.t e, $p'' < 0$ and $d'' > 0$ and hence, $\hat{U} < 0$. That is, $\hat{U}$ is a piecewise concave function of e for $\bar{\imath} \to 0$ (figure below). Also from the functional form it is clear that as $\bar{\imath} \to 0$ and $e \to 0 \Rightarrow p \to 0$. Hence $\hat{U} \to U(\bar{I}) - d(e)$, which is a monotonically decreasing function of e. Hence, from the figure below it is clear that $e = 0$ is the optimal solution.
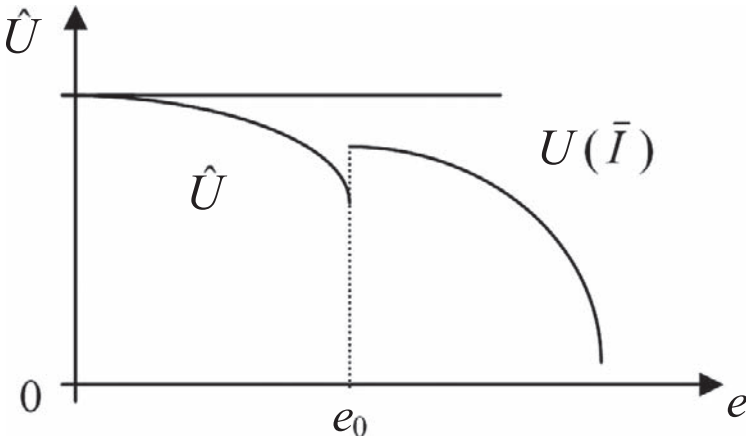
Remark 1: Since the local market is completely captured by the intermediary, and firm owners at Howrah have no information about the possible market outside due to their alienation, the current $\bar{i}$ is close to 0. Thus, this case resembles the situation at Howrah where the firm owner's optimal effort level is 0.

Case 2: Coimbatore

As revealed from our survey, for Coimbatore $\bar{I} = 0$, $\bar{i} > 0$. Hence corresponding expected utility level is $\ddot{U} = p(\bar{i}, e)U(I) - d(e)$ and $\ddot{U} = 0$ when $e = 0$ (Figure 3.2).

Thus we observe that the optimal effort level for a Coimbatore firm owner, $e_{max} > 0$.

Note 3: If in Coimbatore we have a monotonically decreasing curve starting from (0,0), that would imply that the potential entrepreneur would never start the business. Further, once the entrepreneurs start searching the market by themselves their initial level of information increases and hence the above curve possibly would shift up over time leading to a higher level of utility.
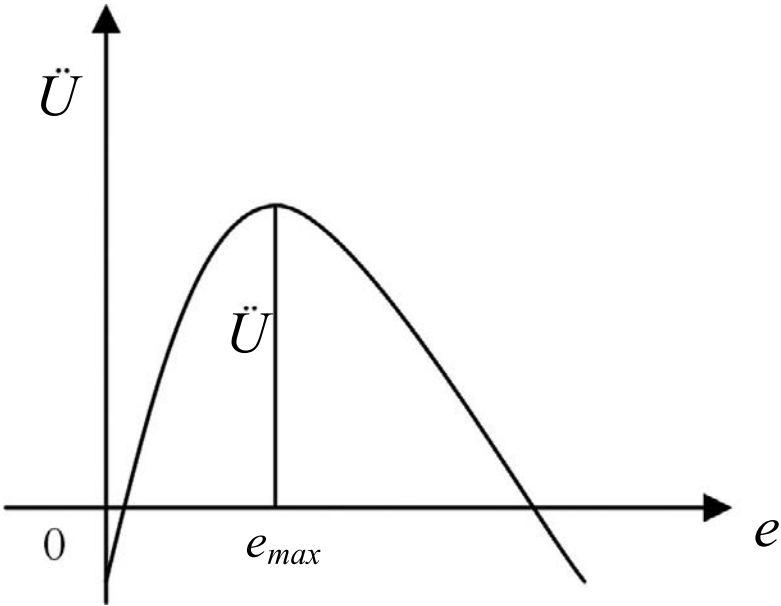
3.10 Policy Implications and Concluding Remarks

In a globalized world, our general policy regarding any sector should shift from being protectionist to helping the firms to be competitive.[19] In particular, for the industry sector, use of modern technology becomes utmost important factor for remaining competitive, and the policy initiatives by the state should address this aspect appropriately.

Further, the two different situations relating to the same industry located at two separate locations show how a uniform policy cover may be ineffective. From the current study of small-scale foundry firms at Howrah, we observe that providing any type of subsidy (with the hope of protecting the SSI sector) to these firms will indeed be a waste of resources. This would furnish further incentive to reduce prices and capture the lower end of the market rather than to enhance investment and productivity. What is lacking in the system is *information* about new technology and the marketing possibilities for the improved products, and the Foundry Association can play a role in this regard.

Owing to the stricter pollution-related norms, in most developed countries, foundry is no longer considered a profitable industry. Thus, for the developing countries there is a potential market for foundry products, provided the quality is maintained. Only when the foundry firms at Howrah are convinced of these (demand) potentials, will investment come forth. Once a critical level of information is provided and investments are made, a virtuous cycle may start. Coimbatore firms, on the other hand, face an entirely different set of problems and hence require a different kind of assistance. Some of the problems the firms at Coimbatore reported are the frequent change of government regulations that in turn create uncertainty and affect investment adversely. Furthermore, export procedures are complicated. Reform in these directions may be useful.

Finally, the issue of "who is an entrepreneur" in the Howrah setup also remains ambiguous. We observe that in the Howrah foundry firms, the coordination of different factors of production is actually in the hands of the intermediary. But importantly, this intermediary has no role to play in making an investment decision. However, in the other parts of India there are examples of business ventures (though a few) where such an intermediary network exists and the intermediary and the capitalist operate in a collaborative fashion to make investment decisions. At Howrah, even with such heavy dependence on the intermediary, mistrust between firm owners and intermediaries prevented such collaboration. Perhaps the reason for such a stalemate lies in the fact that the firms in Howrah were caught up in the broader conflict between labor and management that prevailed in the state of West Bengal during much of 1970s and 1980s, and further because the relationship between intermediary and firm owner could not transcend their earlier relationship as employer and employee.

Notes

[1]Several papers discuss about the role of the small-scale sector in developing nations in general and in India in particular, e.g. see (Gang, 1995, 1992; Desai and Taneja, 1990; Dhar and Lydall, 1961; Anderson, 1982; Ghosh, 1988; Liedholm and Mead, 1986; Suri, 2002; Narasaiah and Margaret, 1999).

[2]Source of the information on SSI sector of India provided in this section, is the web-site of the Ministry of Small Scale Industries, Annual Report, various issues.

[3]Here we take into consideration only the registered small units. The definition of a small-scale unit as of 21.12.99 is an industrial undertaking in which investment in fixed assets in plant and machinery, whether held on ownership terms or lease or hire, does not exceed Rs 10 million.

[4]In this connection see Rao (2002).

[5]Technology for Small-Scale Industries, Small Industries Development Bank SIDBI (2000).

[6]Often due to Government's protectionist policies relating to the SSI sector, a small entrepreneur finds it optimal to remain small and this can be counterproductive (Vepa, 1988).

[7]See also Table 3.2 for the importance of SSI sector (in terms of number of units) in West Bengal.

[8]The basis of such assertion has been discussed in the subsequent section.

[9]The author herself visited the foundries in Howrah and Coimbatore and interacted with the personals. Resource constraints had prevented a large scale survey involving appointed investigators.

[10]From CODISSIA (Coimbatore District Small-scale Industries Association) Bulletins.

[11]From CODISSIA (Coimbatore District Small-scale Industries Association) Bulletins.

[12]For a detailed discussion see Banerjee et al. (2002).

[13]For national simplicity we have used the same probability. Results hold if one assumes a different probability distribution.

[14]For proof of these Propositions see Rajeev (2004).

[15]One can use different notations for profit for Howrah, Coimbatore and intermediary setup. To keep the notations simple, we have not done that.

[16]For proof of these Propositions see Rajeev (2004).

[17]As mentioned above, an intermediary is usually an earlier laborer from the industry with a low education Level. Hence his/her information reach is very much limited to the local market.

[18]Level I might depend on various factors, in particular, on e itself. However, for simplicity, we have assumed it to be fixed.

[19]Regarding policy issues on rural industries see Naik (2002).

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Part II
Empirical Analyses

Chapter 4
Knowledge Based Entrepreneurship and Regional Economic Performance

David B. Audretsch, Werner Bönte, and Max Keilbach

4.1 Introduction

The role and perception of entrepreneurship in society has changed strongly over the last half century. During the post-World War II era, the importance of entrepreneurship and small businesses seemed to be fading away. However, this trend has reversed in the recent years. While in the US, the relative importance of SMEs, measured through average GDP per firm, decreased between 1947 and 1980, it has re-increased since then (Brock and Evans, 1989; Loveman and Sengenberger, 1991; Acs and Audretsch, 1993). Similar evidence is found when considering only the manufacturing industry (Acs and Audretsch, 1990). This trend reversal was not limited to North America. Audretsch et al. (2002) report that business ownership rate in the Netherlands decreased systematically until the beginning of the 1980s only to rise again since then. The same trend is found when measuring the importance of Dutch SMEs though employment shares (EIM, 2002). Similar evidence has been found for Western Germany, Portugal and Italy (Acs and Audretsch, 1993; Audretsch and Thurik, 2001).

Together with this increase in the economic importance, the perception of entrepreneurship in society and public policy is increasing as well. Today, it is difficult to identify a region or a state that does not offer some form of entrepreneurship policy (e.g. Storey, 2003) or some form of entrepreneurship price. The rationale

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behind these policies is the belief that entrepreneurship is able to create new jobs in new technological fields, therefore generate structural adjustments in the economy and ultimately create economic growth.

Audretsch and Keilbach (2005) argue that entrepreneurship plays an important role in the process of knowledge spillovers. Arrow (1962b) states that knowledge as an input to production is inherently different to the more traditional inputs such as labor and capital. This is for two reasons: (1) knowledge has a public goods characteristic, (2) the economic value of knowledge is intrinsically uncertain and its potential value is asymmetric across economic agents.

While the first aspect has been addressed and formalized within the endogenous growth theory (Arrow, 1962a; Lucas, 1988; Romer, 1990, p. S73), the second one has not. Rather, the endogenous growth theory implicitly assumes that knowledge, once it has been generated, spills over more or less "automatically" to other firms.[1] However, transforming generally available new economic knowledge into viable new products or technologies—the essence of knowledge spillovers—requires investments with uncertain outcomes and therefore bears risks.

Often, this investment is made by entrepreneurs. By starting up a business, an entrepreneur literally "bets" on the product he offers (or will be offering) and thus is willing to shoulder the risk that this process bears. He or she does so, since they believe that the potential returns are greater than the potential losses. The economic implication of that process is transformation of generally available knowledge into a new product. Hence entrepreneurship can be considered as an important, though, in our view, neglected mechanism in the transmission of knowledge and the actual spillover process. Acs et al. (2003) refer to the gap between knowledge and commercialized knowledge as the 'knowledge filter'. By commercializing ideas that otherwise would not be pursued and commercialized, entrepreneurship serves as one mechanism facilitating the spillover of knowledge. Thus, entrepreneurship capital promotes economic performance by serving as a conduit of knowledge spillovers.

Baumol and Oates (1988) distinguish this entrepreneurial function explicitly from the role of larger incumbent corporations that are rather engaged into routinized processes of large scale innovation. While these processes are quantitatively more important in that R&D expenditure and the number of patents generated are larger, a number of systematic studies have provided evidence that breakthroughs and new products are rather introduced by small and young firms, i.e. by entrepreneurs.[2] In that sense Baumol and Oates (1988) refer to innovation as an integrated process based on a division of labor between small firms, who launch new products and introduce new technologies, and large firms, who take on these ideas and develop them. Hence entrepreneurial firms and large firms coexist in what Baumol (2002) calls a "*David-Goliath Symbiosis*". In that respect, entrepreneurship plays an important role for the economic dynamics and for the growth process of an economy.

By taking on the risk of developing this uncertain knowledge, entrepreneurs increase the amount of utilized knowledge spillovers. Hence this function of risk taking is an important one in the innovation process. In that spirit, the OECD (1998) states that "Entrepreneurs are agents of change and growth in a market economy and

they can act to accelerate the generation, dissemination and application of innovative ideas. "Entrepreneurs not only seek out and identify potentially profitable economic opportunities but are also willing to take risks to see if their hunches are right."

However, the idea that entrepreneurs play an important economic function by taking on risks is certainly not new. In the 4th book of his *Principles*, Marshall (1920) considered four "agents of production": land, labor, capital and organization. He understood "organization" in a structural sense (i.e. in the sense that the notion "industrial organization" reflects) and also in the sense of an activity. Referring to entrepreneurs as "business men" or "undertakers" he states that: "*They* [i.e. the entrepreneurs] *'adventure' or 'undertake' its risks* [i.e. the risks of production]*; they bring together the capital and the labour required for the work; they arrange or 'engineer' its general plan, and superintend its minor details.*" Marshall (1920, p. 244)

In this respect, the Marshallian "*something in the air*" (Marshall, 1920, p. 225) that is usually cited in connection with spatial knowledge spillovers,[3] does also apply to a regional culture of risk preference and entrepreneurial behavior. In that respect, entrepreneurial behavior can be considered as a capacity of the region to generate entrepreneurship. We define this capacity as the regions' *entrepreneurship capital*. It is the regional milieu of agents and institutions of an economy, a region or a society that is conducive to the creation of new firms. This involves a number of aspects such as social acceptance of entrepreneurial behavior, and of course also individuals who are willing to deal with the risk of creating new firms, and the activity of bankers and venture capital agents who are willing to share risks and benefits involved. Hence, entrepreneurship capital reflects a number of different legal, institutional and social factors and forces.[4] Regions with a high degree of entrepreneurship capital facilitate the startup of new firms based on uncertain and asymmetric ideas. On the other hand, regions with a low degree of entrepreneurship capital impede the ability of individuals to start new firms. Entrepreneurship capital promotes the spillover of knowledge by facilitating the startup of new firms.

As such, entrepreneurship capital is unobservable and can be considered as a *latent variable* (e.g. Bartholomew and Knott, 1999). The model to be presented in Section 4.2 can explicitly deal with this kind of variables. Furthermore, it allows us to investigate the role of entrepreneurship in increasing the permeability of the *knowledge filter*. As argued above, entrepreneurial activity increases the utilization of new knowledge which has been created by incumbent firms. If this argument holds, it is important to distinguish the direct effect of knowledge on economic performance from the more indirect effect of knowledge that is taken on by newly started firms which in turn increase the economic performance. The econometric model which is described in more detail in the following section takes this distinction into account.

The aim of this paper is to investigate empirically the relationship between regional innovative activities, entrepreneurship and economic performance for West-German counties. In particular, we examine whether creation of new technological opportunities through past innovative activities of incumbent firms does lead to an increase in the productivity of a region's manufacturing sector. In doing so, we

distinguish between direct and indirect effects. The latter will occur if technological opportunities positively influence the regions' entrepreneurship capital and in turn productivity. In contrast to previous empirical studies in this field of research we do not employ 'classical regression analysis' but make use of the LISREL method. This is a statistical structural modeling method that allows us to estimate causal relationships among latent variables, like knowledge, entrepreneurship capital and productivity.

The chapter is arranged as follows: in the following Section 4.2 we describe the empirical model used in this study and present the data. Section 4.3 discusses the empirical findings and Section 4.4 concludes the paper.

4.2 Model and Data

We aim at investigating the relationship between technical knowledge, entrepreneurship capital and the level of productivity at the regional level. Based on the theoretical considerations discussed in the introductory section we developed a structural equation model. We analyze the *direct* effect of 'technical knowledge' on 'productivity'. We contribute to the literature by explicitly analyzing the *indirect* effect of 'technical knowledge' through its positive impact on entrepreneurship capital which in turn may positively affect productivity.

Since technical knowledge, entrepreneurship capital and economic performance are hypothetical constructs we treat them as latent variables which cannot be perfectly measured by one indicator but can merely be measured *imperfectly* by multiple indicators. Hence, we take measurement errors into account. In order to analyze linear causal relationships among the variables, we make use of structural equation modeling (SEM) with latent variables. We use the statistical package LISREL which allows us to estimate parameters of the equation system and to present statistical tests for the direct and indirect effects of technical knowledge. For a detailed description of LISREL refer to Jöreskog and Sörbom (2001).

Sample: To estimate this model we make use a data from 310 West-German counties or *Kreise*. The counties are the smallest geographical units for which data of interest can be obtained. One might have doubts, however, whether counties are the appropriate geographical units for our purpose. It could be argued, for instance, that the institutional background, like propriety rights or administrative barriers, which is important for the ability of individuals to start new firms is country- or state-specific rather than county-specific. Then one would expect a high variation of entrepreneurship capital between countries or states but not between counties. Our data, however, show a lot of variation at the county level suggesting that the endowment with entrepreneurship capital is at least to some extent county-specific.

Entrepreneurship Capital: Observed indicators for this latent variable are cumulated numbers of startups in high-tech or ICT industries within a county in the years 1998–2000, relative to the county's population. Thus, we assume that the entrepreneurship intensity is higher the higher the level of the latent variable

'entrepreneurship capital' is. A high-tech industry is defined as one whose share of R&D employment in total employment is above 2.5%. ICT industries comprise products and services that are related to information and communication technologies. For a further discussion of this measure see Audretsch and Keilbach (2004b).

Productivity: The observed indicators for the latent variable productivity are the level of average labor productivity (output/labor input) and the level of average capital productivity (output/capital input) in a region's manufacturing sector. This latent variable is related to well-known measures of total factor productivity (TFP) because the productivity of both, labor as well as capital inputs, is taken into account (see Solow (1957)). However, while one has to make restrictive assumptions about the payment of inputs and the degree of competition when computing traditional TFP measures, this is not the case for our approach. We have restricted our attention to the productivity of the manufacturing sector, because the bulk of private innovation efforts is is performed within this sector and we therefore expect the direct as well as indirect effects of technical knowledge on productivity to be stronger in the manufacturing sector than in other sectors.

Output is measured as Gross Value Added in year 2000 of the manufacturing industries corrected for purchases of goods and services, VAT and shipping costs. The stock of *Physical Capital* used in the manufacturing sector of the *Kreise* has been estimated using a perpetual inventory method, which computes the stock of capital as a weighted sum of investments done in the producing sector in the period 1980–2000. For a more detailed description of this procedure see e.g. Audretsch and Keilbach (2004b). Statistics including output and investment are published every two years in the level of *Kreise* by the Working Group of the Statistical Offices of the German Länder, under "Volkswirtschaftliche Gesamtrechnungen der Länder". *Labor* is expressed as the number of employees in the manufacturing industries in 2000. This data is published by the Federal Labor Office, Nürnberg that reports the number of employees liable to social insurance on the level of German counties.

New Knowledge: In empirical practice it is common to use R&D efforts or patents to proxy for a region's innovative activity. While R&D may be regarded as an input, patents tend to measure the innovative output. However, not all the innovative outputs are patented by firms (Griliches, 1990). We make use of both indicators. The observed indicator for latent variable 'innovation input' (R&D) is a region's *R&D Intensity*, is measured as the number of non-public R&D-employees in all industries relative to our measure of labor for the years 1987, 1991 and 1995. This data has been provided by the Stifterverband für die Deutsche Wissenschaft. The observed indicators for the latent variable 'innovation output' (*technical knowledge*) is a region's number of patents relative to our measure of labor. We use German patent data for the years 1995 and 1996. This data is taken from Greif and Schmiedl (2002). These proxy measures for knowledge are taken for periods before 1998 since it is unlikely that R&D takes an immediate effect on entrepreneurship capital and output.

4.3 Empirical Findings

In this section we present the results of a maximum likelihood estimations of variants of the model described in Section 4.2. Since by its very nature the structure of the model is more complex than that of the general linear model, it is convenient to display the results in graphical form. More detailed estimation results are reported in the Tables 4.1 and 4.2.

Figure 4.1 shows the impact of latent variable 'technical knowledge' where the observed indicators of this variable are the patent intensities in 1995 and 1996 (model A).[5] Figure 4.2 is based on the same structure as the previous model (Fig. 4.1), however this time, we use an *input*-measure of innovation, namely the regional R&D-intensity (model B).

The estimation results for models A and B suggest that a region's technical knowledge (R&D) has a direct, positive and significant impact on productivity of the manufacturing sector. Moreover it is also positively linked to a region's entrepreneurship capital, which in turn seems to increase the level of productivity of the manufacturing sector. All these relations are measured positive and statistically significant.

Table 4.1 Estimation results: Model A

Latent variables	Observed variables	Parameter	Estimate	(S.E.)
Knowledge (ξ)	Patents 95	λ_{11}^{x}	0.99	(0.03)
	Patents 96	λ_{21}^{x}	1	
Productivity (η_1)	Labor productivity	λ_{31}^{y}	1	
	Capital productivity	λ_{41}^{y}	1.12	(0.24)
Entrepreneurship	High-tech start ups	λ_{12}^{y}	1	
capital (η_2)	ICT start ups	λ_{22}^{y}	0.69	(0.06)
		β_{12}	0.05	(0.02)
		γ_{11}	0.11	(0.02)
		γ_{21}	0.32	(0.04)
		$var(\zeta_1)$	0.01	(0.00)
		$var(\zeta_2)$	0.19	(0.02)
		$\theta_{11}^{\varepsilon}$	-0.02	(0.02)
		$\theta_{22}^{\varepsilon}$	0.06	(0.01)
		$\theta_{33}^{\varepsilon}$	0.02	(0.00)
		$\theta_{44}^{\varepsilon}$	0.10	(0.01)
		θ_{11}^{δ}	0.03	(0.01)
		θ_{22}^{δ}	0.03	(0.01)
		χ^2	8.31	$P = 0.21$
		d.f.	6	
		AGFI*	0.97	
		RMSEA**	0.035	

Notes: *Adjusted goodness of fit index,
       **Root mean squared error of approximation.

Table 4.2 Estimation results: Model B

| Latent variables	Observed variables	Parameter	Estimate	(S.E.)
Knowledge (ξ)	R&D 87	λ_{11}^{x}	0.95	(0.05)
	R&D 91	λ_{21}^{x}	1	
	R&D 95	λ_{31}^{x}	1.11	(0.10)
Productivity (η_1)	Labor productivity	λ_{31}^{y}	1	
	Capital productivity	λ_{41}^{y}	0.48	(0.27)
Entrepreneurship	High-tech start ups	λ_{12}^{y}	1	
capital (η_2)	ICT start ups	λ_{22}^{y}	0.77	(0.05)
		β_{12}	0.09	(0.03)
		γ_{11}	0.04	(0.02)
		γ_{21}	0.34	(0.04)
		$var(\zeta_1)$	0.03	(0.02)
		$var(\zeta_2)$	0.13	(0.02)
		$\theta_{11}^{\varepsilon}$	0.01	(0.01)
		$\theta_{22}^{\varepsilon}$	0.05	(0.01)
		$\theta_{33}^{\varepsilon}$	0.00	(0.02)
		$\theta_{44}^{\varepsilon}$	0.11	(0.01)
		θ_{11}^{δ}	0.28	(0.05)
		θ_{22}^{δ}	0.56	(0.07)
		θ_{33}^{δ}	0.32	(0.06)
		θ_{21}^{δ}	0.22	(0.05)
		χ^2	13.28	$P = (0.21)$
		d.f.	10	
		AGFI*	0.97	
		RMSEA**	0.033	

After initial estimation we relaxed the zero restriction on θ_{21}^{δ} since modification indices suggested that this improves the fit of the model.
*Adjusted goodness of fit index,
**Root mean squared error of approximation.
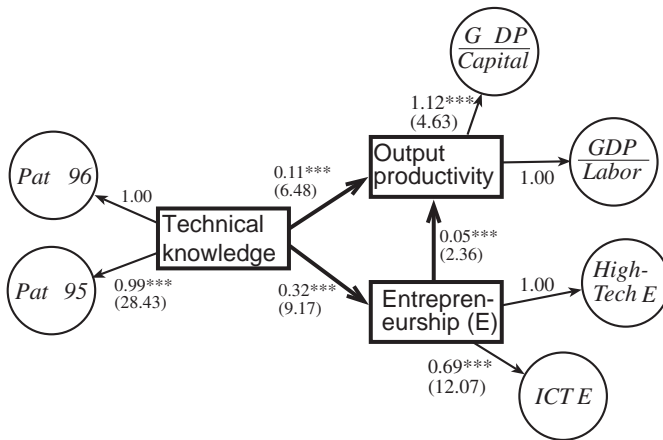
Fig. 4.1 Technical knowledge, entrepreneurship capital and productivity in the manufacturing sector: Model A
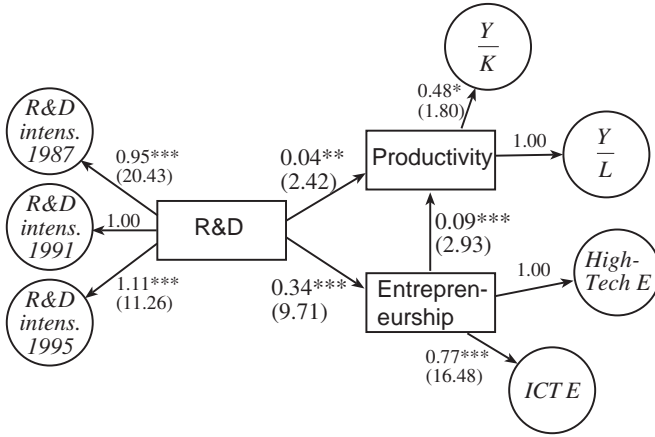
Fig. 4.2 Innovation input (R&D), entrepreneurship capital and productivity in the manufacturing sector: Model B

Global fit indicators suggest that the models fit the data very well (see Tables 4.1 and 4.2). The χ^2-statistic of model A is 8.31 ($P = 0.21$) at 6 degrees of freedom and that of model B is 13.28 ($P = 0.210$) at 10 degrees of freedom.[6]

We turn now to the discussion of the *direct* effects, the *indirect* effects as well as the *total* effects of exogenous and endogenous latent variables.

In model A the estimated direct effect of the latent variable 'technical knowledge' on the latent variable 'productivity' is 0.11 (with a *t*-value of 6.48) and the indirect effect on productivity via entrepreneurship capital is 0.02 (with a *t*-value of 2.36). Consequently, the total effect of an increase in technical knowledge on productivity is 0.13 with a *t*-value of 8.07, i.e. significant at $\alpha = 0.01$. Thus an increase in technical knowledge by 1% leads to an increase in productivity by 0.13%.[7]

In model B the estimated direct effect of the the latent variable 'innovation input (R&D)' is 0.05 (with a *t*-value of 2.42) and the indirect effect on productivity is 0.04 (with a *t*-value of 2.42). The total effect of an increase in the latent variable 'innovation input (R&D)' is estimated as 0.09 (with a *t*-statistic of 5.37). As this model makes evident, the direct impact of 'innovation input (R&D)' on productivity of the manufacturing sector is weakly significant whereas there is a strong positive and significant impact on the regions' entrepreneurship capital. Hence a region's entrepreneurship capital seems to increase the impact of industrial R&D on productivity substantially.

We have also tested a model where patents and R&D are assumed to be indicators of the same latent variable 'technical knowledge' but the global fit indicators suggest that they are indicators of two distinct latent variables.[8] Thus, both innovation input and innovation output may capture different aspects (channels) of knowledge diffusion and may thus be conducive to entrepreneurial activity in the high-tech and ICT industries.

Hence we identify two channels by which knowledge has an impact on productivity of a region's manufacturing sector. On the one hand, parts of the technical knowledge in a region is taken on by incumbent firms, increasing productivity of a region's manufacturing sector directly. On the other hand, parts of that technical knowledge is taken on by newly created firms that in turn increase the level of productivity as well. Note however that both trajectories describe distinct processes. While new knowledge within incumbent firms increases the level of productivity within the existing production process, entrepreneurial activity increases it through the creation of new firms.

4.4 Summary and Conclusion

In this chapter, we ask "What is the contribution of entrepreneurship to the dissemination and utilization of new technical knowledge?" and then "What is the impact of this process on regional economic performance?" While the endogenous growth theory assumes knowledge to spill over automatically to all existing firms, we argue that this is actually not the case since new economic knowledge is intrinsically uncertain. Therefore, developing new knowledge is risky and new knowledge is not fully transformed into new products by incumbent firms. This creates opportunities for newly created firms to develop new products on the basis of this "unused" new knowledge. Entrepreneurs are agents who shoulder this risk and by this process increase the yield of new knowledge; hence entrepreneurship is one mechanism in the process of knowledge spillovers.

Seen through the lens of endogenous growth theory, these arguments define several mechanisms. First, while new knowledge will increase the economic performance of an economy or a region, it will not do so at full extent. Parts of the new knowledge will be taken on by entrepreneurs, hence new knowledge will increase the level of entrepreneurship in an economy or a region. Second, by this very process, entrepreneurship will increase the exploitation of new knowledge and as such have a positive impact on regional economic performance. Thus, we suppose that new knowledge has a direct positive effect on regional economic performance and an indirect positive effect via entrepreneurial behavior. Since both mechanisms are closely intertwined, we aim to model them simultaneously. A straightforward way to do so is by referring to structural equation modeling, an approach that allows for reciprocal causation, simultaneity and interdependence.

A second reason to use this approach is as follows. We denote the capacity of an economy or a region to generate firm start-ups as *entrepreneurship capital*. This concept covers political as well as institutional, economic and personal characteristics. As such, entrepreneurship capital is an unobservable hence latent variable. Structural equation modeling allows us to explicitly deal with this type of variable.

Using data for West-German counties, we test the above hypotheses using different proxies for new technical knowledge, one being input oriented (R&D) one rather output oriented (patents). We obtain the following results. First, new knowledge

has a positive and significant impact on economic performance. Moreover, new knowledge has a significant positive impact on the regions' entrepreneurship capital which in turn has a significant positive impact on economic performance. Hence we can indeed identify knowledge to increase the regions' entrepreneurship capital and moreover that entrepreneurship capital to increase the regions' economic performance. Thus we find evidence for the above hypotheses.

A straightforward policy implication would be that in a knowledge based economy it is not sufficient to focus policies to generate stronger economic growth on the generation of new knowledge. Equally important is the exploration and use of new knowledge. Entrepreneurship is one mechanism that goes in that direction.

Notes

[1] This view has been challenged by the literature on absorptive capacity (Cohen and Levinthal, 1990).

[2] Scherer (1980) or CHI Research Inc. (2002). The U.S. Small Business Administration (1995, p.114) enumerates some 70 important innovations by small firms in the 20th century, ranging from low-tech innovations such as the zipper or bakelite to high-tech ones such as the nuclear magnetic resonance scanner or the microprocessor.

[3] See Keilbach (2000, Chapter 3) for a review.

[4] In that respect the notion of entrepreneurship capital is close to the one of social capital (e.g. Putnam, 1993), though not identical. See Audretsch and Keilbach (2004a) for an in-depth discussion of this issue.

[5] All values of the indicators are transformed to logarithms.

[6] P denotes the p-value or exact significance level. RMSEA (Root Mean Squared Error of Approximation) is below 0.05 for all three models which means a very good fit. Moreover, the Adjusted Goodness of Fit Index (AGFI) is 0.95 or higher for all models where values above 0.9 indicate a very good fit. See Jöreskog and Sörbom (2001) for the details of global fit indicators.

[7] Note, that all values of the observed indicators are transformed to logarithms.

[8] Scatter plots of the observed indicators R&D and patents show that these are not very strongly correlated.

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Chapter 5
What Determines Self-employment Choice in India?

Jagannadha Pawan Tamvada

5.1 Introduction

In the last two decades, a vast literature has emerged that aims to explain the characteristics of entrepreneurs, the determinants of occupational choice of individuals and the contexts that promote entrepreneurship.[1] However, until recently, the entrepreneurship literature has largely ignored the labor markets of developing countries.

Beginning with the labor surplus model of Lewis (1954), the labor markets of developing countries are viewed as segmented dualistic markets along the formal-informal lines (also see Sen, 1966; Ranis and Fei, 1961; Harris and Todaro, 1970).[2] Some studies find evidence against these theories of low level subsisting self-employment in LDCs (Majumdar, 1981; Blau, 1986; Rosenzweig, 1980; Mohapatra et al., 2007). Thus, more recently, a growing body of literature attempts to capture the heterogeneity within the informal sector. This strand of literature argues that the informal sector is a blend of both disadvantaged and competitive sectors (Cunningham and Maloney, 2001; Fields, 2005; Günther and Launov, 2006) and claims simultaneous presence of disadvantaged "lower" and voluntary "upper" tiers within the informal sector. Maloney (2004, p. 1159) notes that "as a first approximation we should think of the informal sector as the unregulated, developing country analogue of the voluntary entrepreneurial small firm sector found in advanced countries, rather than as a residual comprised of disadvantaged workers rationed out of good jobs."

As most empirical research on the determinants of self-employment is based on data from the developed economies, the results of this chapter will stand comparable to the results of earlier studies if both the formal and informal sectors are considered together. As Parker (2004, p. 106) summarizes the broadly agreed determinants of

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entrepreneurship in developed countries, "the clearest influences on measures of
entrepreneurship (usually the likelihood or extent of self-employment) are age, labor
market experience, marital status, having a self-employed parent and average rates
of income tax (all with positive effects). Greater levels of risk and higher interest
rates generally have negative effects, although to date only a handful of studies have
satisfactorily investigated the former."

This paper analyzes a large scale database collected in India. Household level
data collected by the National Sample Survey Organization (NSSO) in 2004 are
used for the empirical analysis. The effects of individual personal characteristics,
educational background, household characteristics and non-linear effects of contin-
uous covariates such as age, on the probability of being self-employed are estimated
using simple probit models. The results suggest that educated individuals are less
likely to choose self-employment. Consistent with earlier empirical studies on the
determinants of entrepreneurship, the results suggest that Indian males, married and
older citizens are more likely to be self-employed.

The next section discusses the dataset. The third section presents the empirical
analysis. The final section provides conclusions and discusses possible avenues for
future research.

5.2 Data

The data used for the analysis is the 60th round employment-unemployment survey
of the NSSO of India conducted in 2004. As the focus of the paper is on economi-
cally active individuals, we restrict the sample to those who are older than 15 years
but younger than 70 years. The principal economic activity of this sample ranges
from domestic duties to full time employment (in the form of salaried employment,
self-employment, casual labor or unemployment).

We further drop individuals who are unpaid family workers, students, work-
ers involved in domestic duties, pensioners, those who are unable to work due to
disabilities and people who reported to belong to the occupational class 'other'.
This reduces the final sample to 88,623 economically active individuals. We thus
only consider those who have reported their primary occupation as self-employed
(includes own account workers and employers), salaried employees, casual laborers,
or unemployed. [3]

The descriptive statistics in Table 5.1 show that 65% of the individuals have
attended at least primary school, 65% live in rural areas and 40% are in the agricul-
tural sector. In the absence of an appropriate measure for wealth, we proxy it using
the land-possed by the household. We thus posit that individuals who own large
areas of land are more likely to be self employed.[4]

Table 5.1 Descriptive statistics

Variable	Mean	Standard deviation
Self-employed	0.43	0.50
Salaried	0.24	0.43
Casual labor	0.27	0.45
Unemployed	0.06	0.23
Hinduism	0.79	0.41
Islam	0.11	0.32
Christianity	0.06	0.23
Sikhism	0.01	0.12
Jainism	0.003	0.05
Buddhism	0.01	0.10
Other religions	0.01	0.11
Backward caste (SC)	0.13	0.33
Backward tribe (ST)	0.18	0.39
Backward others (OB)	0.37	0.48
Backward class	0.68	0.47
Forward caste	0.32	0.47
Age	37.13	12.88
Male	0.81	0.39
Female	0.19	0.39
Unmarried	0.21	0.41
Married	0.74	0.44
Divorced	0.04	0.21
No education	0.26	0.44
Informal education	0.09	0.28
Primary	0.31	0.46
High School	0.23	0.42
University diploma/degree	0.12	0.33
No technical education	0.95	0.22
Technical degree	0.01	0.09
Technical diploma	0.04	0.20
Rural	0.65	0.48
Urban	0.35	0.48
Land (>0.4 and <2 hectares)	0.24	0.42
Land (>2 hectares)	0.08	0.27

5.3 Empirical Results

Two binary probit models are estimated to investigate the determinants of the self-employment status. In the first model we consider age, gender, marital status, education, urban location, religion, backward class membership and being in agriculture sector as determinants of self-employment status. In the second model, we introduce the land variables to control the effect of household wealth on self-employment status.

The results in Table 5.2 show that the probability of being self-employed increases with age. The age-squared term is significant suggesting that the effect

Table 5.2 Determinants of entrepreneurship

Independent variables	Model I (*without land controls*)	Model II (*with land controls*)
Personal characteristics		
Age	0.0344***	0.0352***
	(0.0027)	(0.0027)
Age square	−0.0143***	−0.0180***
	(0.0032)	(0.0033)
Female	−0.447***	−0.406***
	(0.013)	(0.014)
Married	0.229***	0.267***
	(0.016)	(0.016)
Divorce/widow	0.351***	0.425***
	(0.029)	(0.029)
General education		
Informal education	0.298***	0.254***
	(0.018)	(0.019)
Primary school	0.401***	0.319***
	(0.014)	(0.014)
High school	0.337***	0.196***
	(0.015)	(0.016)
Diploma/university education	0.0195	−0.165***
	(0.019)	(0.019)
Technical education		
Technical degree	−0.168***	−0.125**
	(0.053)	(0.053)
Technical diploma	−0.110***	−0.103***
	(0.025)	(0.025)
Household controls		
Location = urban	−0.0161	0.227***
	(0.012)	(0.012)
0.2<Land<0.4 hectares		0.132***
		(0.013)
0.4<Land<2 hectares		0.770***
		(0.016)
Land>2 hectares		1.130***
		(0.022)
Hindu	−0.180***	−0.207***
	(0.013)	(0.013)
Backward	−0.227***	−0.189***
	(0.011)	(0.011)
Agriculture	0.517***	0.330***
	(0.012)	(0.012)
Constant	−1.830***	−2.126***
	(0.051)	(0.053)
Total observations	87236	87175
Log likelihood	−50723	−48352
LR χ^2	17603	22258
Deg. of freedom	49	52
Pseudo R^2	0.148	0.187

Notes: *Signifies $p < 0.05$; **Signifies $p < 0.01$; ***Signifies $p < 0.001$. Standard errors are reported in parentheses. Dependent variable is primary occupation of the individual. Base categories for marital status, general education, technical education, land dummies are unmarried, no general or technical education and less than 0.2 hectares of land respectively. Full set of state level regional dummies are also included in the regression.

is increasing and non-linear. This is consistent with findings of empirical literature on developed countries (Blanchflower and Meyer, 1994; Blanchflower, 2000) that older individuals are more likely to be self-employed. As Fuchs (1982, p. 356) claims: "Men who change to self-employment late in life are primarily those who have had previous experience in self-employment or who are in wage-and-salary occupations such as managers or salesmen that have many characteristics similar to self-employment."

The results further suggest that both married and divorced people are more likely to be self-employed compared to unmarried individuals.[5] Marriage reduces entrepreneurial risk if the spouse is economically active. It also provides an additional unpaid family worker for the household enterprizes. It is also possible that marriage gives additional money in the form of dowry, which can enable start-up activity.[6]

The positive coefficients of the education variables of informal and school education suggest that lower levels of education are positively related to self-employment. The negative coefficient of the variable 'University', however, suggests that higher education decreases the probability of self-employment. People with technical education may choose to be self-employed as their professional training enables this possibility. For this reason, we introduce technical education dummies in the estimation, with "having no technical education" as the base variable. The results suggest that the effect of having technical degree is insignificant and having a technical diploma is negative and significant at the 5% level. This is possibly because the foregone professional earnings for individuals with a technical degree is much higher than for those with a diploma.

The results also suggest that Hindus and members of backward castes are less likely to be self-employed. This remarkable observation is analyzed in greater detail in Audretsch et al. (2007). In the second specification, we introduce the land variables. We introduce the land variables as there are compelling reasons to assume that wealth determines the entrepreneurial choice, in the Indian context.[7] The probability to be self-employed also increases with the wealth of the individual's household, proxied here by the land variables. State level regional dummies are included in the estimated regressions. The coefficients suggest that there is considerable variation in the entrepreneurial propensity in different regions. An in-depth analysis underscoring the role of spatial location is dealt by Tamvada (2007).

In the second specification, the introduction of land variables decreases the coefficients of the education variables. This suggests that the education variables, in first model, captured the effects of the land variables. In particular, it is seen that the coefficient of the University education variable turns negative and significant in the second model. Thus, the empirical results suggest that higher education reduces self-employment participation, in the Indian context.

5.4 Conclusion

The field of entrepreneurship in economics provides insights into the individual determinants of the self-employment choice in developed countries. We contribute to one aspect of this literature that remained neglected for a long time. We examine individual determinants of self-employment choice in a developing country, India. Consistent with studies based on datasets from developed countries, we find age to have a non-linear relationship with the probability to be self-employed. Married individuals are more likely to be self-employed. Educated people are less likely to be self-employed. This leads to an important conclusion that self-employment in Indian context may actually support the view that self-employment in a fast growing economy like India continues to be the main occupational option for individuals with low human capital.

Notes

[1] See Parker (2004, for a survey of this literature) and Tamvada (2007) for a detailed study on entrepreneurship in India.

[2] Harris and Todaro (1970) predicts that workers who migrate from rural to urban areas face unemployment and are forced to work in household enterprizes at subsistence levels.

[3] We merge the occupations into self-employment and paid-employment for the rest of the analysis in this chapter.

[4] While in agriculture, land enables self-employed farming, and this makes people to choose self-employment over other modes of occupation, in the nonagricultural sector, land serves as potential collateral to obtain credit for starting an enterprize.

[5] This is consistent with Fairlie and Meyer (1996) and other studies that find positive effects of marital status on self-employment.

[6] Though dowry is legally prohibited in India, it is prevalent in numerous forms.

[7] One of the primary reasons for keeping these indicators of household wealth is that there is evidence of the financial institutions rationing credit to individuals who are able to provide collateral. This indicates that wealth should strongly predict the self-employment choice as lack of finance is one of the biggest obstacles to being self-employed.

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Chapter 6
Entrepreneurship and Innovative Policies for Financing Small Scale Industries in India: An Empirical Analysis

M. H. Bala Subrahmanya and Rumki Majumdar

6.1 Introduction

Small Scale Industries (SSI) play a pivotal role in the employment generation and export promotion strategies, among others, of industrialization in many developed as well as developing countries including India. Considering their unique features, governments in both industrialized and developing countries provide a wide variety of programmes to assist small and medium scale enterprizes (Hallberg, 2000). The primary justifications for the special policy support to SSI are: they have the capacity to produce a large number and variety of goods with relatively low investment, that they offer greater employment opportunities per unit of capital investment as compared to large enterprizes and that the scope for organizing their growth on a decentralized pattern over a large area results in achieving distinct socio-economic advantages such as better and fuller utilization of untapped resources of capital and skill and more equitable distribution of national income. It is appropriate, therefore, that each country should have developed its own strategy for the development of SSI and has offered liberal concessions and attractive incentives for entrepreneurship growth and SSI development (DCSSI, 1971).

SSI on the whole has bright prospects, but due to individual enterprize's weakness in scale and limitations in personnel, information, management and especially financing, the development of these enterprizes does not go smoothly (Wang, 2004). Particularly, improving the SSI entrepreneur's access to financing services is justified on the ground that a robust industrial base contains a flourishing SSI sector and that increasing SSI access to services normally available to larger, established firms

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would further boost industrial growth and income distribution objectives (Webster, 1989).

'Economic growth with social justice' being the primary objective of India's Social and Economic Policy, India accorded a place of strategic importance to SSI in its economic development strategy since independence. SSI being labor-intensive had the positive implications of equity, flexibility and capability to contribute to decentralization, promotion of entrepreneurship, optimum utilization of local resources and talents, etc. (DCSSI, 2002). SSI has some common problems in all countries and perhaps the most basic problem is the lack of adequate capital and credit facilities for sustaining their growth and development. Credit is an essential input for industry, more so in the case of SSI which has a weak capital base. Recognizing the importance of SSI and its need for adequate credit facilities from institutional sources, Indian Policy Makers have formulated several suitable measures from time to time (DCSSI, 1971).

Given this backdrop, this paper is an attempt to probe the evolution of SSI financing policy, financial infrastructure, growth of bank financial assistance to SSI and its influence on SSI performance over a period of time. Whether and how financing policy, bank financial assistance growth and influence on SSI performance in the globalization period are different from that of pre-globalization period is analyzed. The chapter is structured to comprise four sections. Section 6.2 deals with the evolution of SSI financing policy and financial infrastructure in India since independence and Section 6.3 describes the growth of SSI financing in India, particularly with reference to bank finance, analyzes the varying significance of bank finance in SSI output and the influence of the former on the latter. Section 4 presents summary and conclusions.

6.2 Evolution of SSI Financing Policy in India

Availability of timely and adequate financial assistance is *sine qua non* for the growth of any sector including SSI. Like any other sector, SSI entrepreneur needs two types of funds:

1. Term Capital or Long-Term Funds
2. Working Capital or Short-Term Funds

Term capital or long-term funds are required for the creation of fixed assets like land, building, plant and machinery and other capital assets. Working capital is the fund that an entrepreneur needs to carry on the day-to-day business like purchase of raw materials, electricity, water and payment of wages and salaries, etc. (DCSSI, 1971; SIDBI, 1999).

To meet the diverse financial needs of SSI entrepreneurs, several institutional arrangements have been made by the Government of India, over a period of time. A very firm foundation in this regard was laid during the Second Five Year Plan Period (1956–61) with the establishment of the State Financial Corporations (SFCs) by various state governments for granting term loans to SSI for acquiring fixed assets.

During the same period, State Bank of India (SBI) had also drawn up a comprehensive scheme for providing financial assistance on liberal terms to SSI. In course of time, other commercial banks in the private sector followed suit and started giving financial support to SSI (DCSSI, 1971). The setting up of National Small Industries Corporation (NSIC) in 1956 followed by State level Small Industries Development Corporations (SIDCs) set up by a few State Governments for supplying imported and indigenous machinery on hire purchase basis represents another dimension of financial assistance provided to SSI. Thus by the late 1950s, financial infrastructure for SSI had taken a definite shape where "term loan" needs of the sector were met by SFCs and the state governments under the State Aid to Industries Act, supplemented by the support of NSIC and SIDCs. Whereas "short-term credit" needs were met by SBI and commercial banks. To induce the commercial banks to expand their lending to SSI entrepreneurs, Government of India started a Credit Guarantee Scheme in 1960, under which loans granted to the sector are insured against losses on account of bad debts (DCSSI, 1971).

The establishment of Industries Development Bank of India (IDBI) in 1964 represents another milestone in the development of financial infrastructure for SSI entrepreneurs (SIDBI, 1999). A significant responsibility of IDBI was to cater to the long-term credit needs of SSI entrepreneurs, among others. Till April 1990, IDBI as the principal financial institution for coordinating the activities of institutions engaged in financing, promoting and developing industry, was also assisting SSI. IDBI had taken a number of measures to promote the flow of term finance to SSI entrepreneurs. Its assistance was indirect, by way of refinance through SFCs and banks; it also provided assistance to SIDCs. IDBI also operated a scheme for rediscounting bills arising out of the sale of indigenous machinery on deferred payment basis (RBI, 1992).

After the nationalization of 14 commercial banks in 1969, Government of India defined what is known as "the priority sector" to comprise agriculture, SSI, small business, small road and water transport operators, among others and stipulated that 40% of the net bank credit should flow to this priority sector. However, among the constituents of priority sector, the emphasis was to be on agriculture, SSI and small business (Chandrasekhar, 2005).

In 1982, government of India took another major step towards providing greater financial support to SSI entrepreneurs, among others, in the rural sector by setting up the National Bank for Reconstruction & Development (NABARD). NABARD is established as a development bank "for providing and regulating credit and other facilities for the promotion and development of agriculture, small scale industries, cottage and village industries, handicrafts and other rural crafts and other allied economic activities in rural areas with a view to promoting integrated rural development and securing prosperity of rural areas and for matters connected therewith or incidental thereto." (NABARD website).

However, perhaps the most historic development with reference to the financial infrastructure for SSI entrepreneurs was the setting up of Small Industries Development Bank of India (SIDBI) as a wholly owned subsidiary of IDBI, to cater to the needs of SSI as an apex financial institution, in 1990. SIDBI has to serve

as the principal financial institution for the promotion, financing and development of Indian industry in the small-scale sector and to coordinate the functions of the institutions engaged in similar activities. Significant responsibility was entrusted to the bank to assist the entire spectrum of SSI sector including tiny village and cottage industries in the decentralized sector (SIDBI, 1999). SIDBI was de-linked from IDBI with effect from 27th March 2000. SIDBI today provides direct as well as indirect assistance for the overall development of SSI through a network of 5 regional offices and 33 branch offices spread across the country (DCSSI, 2002).

Thus by the 1990s, Government of India has developed an extensive financial infrastructure to meet the diverse credit needs of SSI entrepreneurs across the country (Table 6.1).

The onset of economic liberalization in 1991 marks another step in the development of financial policy for SSI in India. The exclusive 'policy measures for promoting and strengthening small, tiny and village enterprizes' emphasized the need for shifting from subsidized/cheap credit to adequate flow of credit (Ministry of Industry, 1991). The policy proposed significant measures to overcome the financial weaknesses of SSI:

1. Equity participation by other industrial undertakings in SSI not exceeding 24% of the total shareholding.
2. Limited Partnership Act to enhance the supply of risk capital to SSI. Such an Act would limit the financial liability of the new and non-active partners/entrepreneurs to the capital invested.
3. "Factoring services" introduced by SIDBI to spread throughout the country through commercial banks.
4. A suitable legislation to be introduced to ensure prompt payment of SSI bills by its customers.

Since then, four Expert Committees have been set up to look into the problems of SSI from time to time:

1. Nayak Committee (1991–92)
2. Abid Hussain Committee (1995–97)

Table 6.1 Financial infrastructure for SSI in India

Institutions for term loans	Institutions for working capital
1. Small Industries Development Bank of India (SIDBI)- Apex Bank	1. Commercial banks
2. National Bank for Reconstruction and Development (NABARD)	2. Co-operative banks
3. State Financial Corporations (SFCs)	3. Regional rural banks
4. National Small Industries Corporation (NSIC)	
5. State Small Industries Development Corporations (SSIDCs)	

Source: RBI (1992).

3. Kapur Committee (1997–98)
4. S P Gupta Committee (2000–01)

Of these, Nayak Committee and Kapur Committee exclusively dealt with the credit problems of the sector. Some of the major initiatives that have been taken as a result of the recommendations of these Expert Committees, since the early 1990s, are:

1. Earmarking of credit for tiny sector within overall lending to SSI.
2. Enactment of Delayed Payments Act in 1993.
3. Opening of specialized SSI bank branches. As of March 2002, 391 specialized SSI branches are working in the country.
4. Introduction of "factoring services" by Public Sector Banks.
5. Establishment of National Equity Fund (NEF). NEF under SIDBI provides equity type assistance to SSI units and tiny units at 5% service charges. The scheme has provision for a loan up to Rs. 1 million and project cost limit from Rs. 2.5 million to Rs. 5 million.
6. Technology Development & Modernization Fund (TDMF) through SIDBI. TDMF scheme provides for direct assistance to SSI to encourage existing industrial units in the sector to modernize their production facilities and adopt improved and updated technology so as to strengthen their export capabilities. Assistance under the scheme is available for meeting the expenditure on purchase of capital equipment acquisition of technical know-how, up-gradation of process technology and products with thrust on quality improvement, improvement in packaging and cost of TQM and acquisition of ISO-9000 series certification. Non-exporting units and units that are graduating out of SSI sector, are also eligible to avail assistance under this scheme.
7. Enhancement of composite loan limit to Rs. 5 million from Rs. 2.5 million. Composite loan scheme is meant for equipment and/or working capital and also for work-sheds to artisans, village and cottage industries in tiny sector.
8. No collateral security for loans up to Rs. 2.5 million.
9. Launch of Credit Guarantee Scheme to cover loans up to Rs. 2.5 million.
10. Launch of Credit Linked Capital Subsidy Scheme (CLCSS) to provide for subsidy against loans taken for technology up-gradation. Under this scheme, ceiling on loans was raised from Rs. 4 million to Rs. 10 million with effect from 29th September 2005, and the rate of subsidy from 12 to 15%.
11. Enhancement of project cost limit under National Equity Fund to Rs. 5 million.
12. Introduction of Laghu Udyami Credit Card (LUCC) by Public Sector Banks for providing simplified and borrower friendly credit facilities to SSI, tiny enterprizes and artisans.
13. Interest rate band of 2% above and below Prime Lending Rate (PLR)
14. Reserve Bank of India (RBI) formulated the scheme of "Small Enterprizes Financial Centres" (SEFC) to encourage banks to establish mechanisms for better coordination between their branches and branches of SIDBI in the identified clusters for more efficient credit delivery
15. Working group to be set up on flow of credit to SSI

Overall, the emphasis of these policy measures has been, among others, to facilitate SSI entrepreneurs to overcome technological obsolescence and shortage of working capital in the era of economic liberalization.

6.3 Growth of SSI Entrepreneurship, Production and Scheduled Commercial Banks' (SCBs) Advances

Given the financial infrastructure and policy measures for improving the credit flow to SSI, it is appropriate to understand how bank finance to SSI has grown vis-à-vis SSI production and number of SSI enterprizes over a period of time. Our analysis is confined to bank finance and not the entire financing of SSI due to the availability of time-series data for scheduled commercial banks' (SCBs') advances to SSI. RBI data on SCBs' advances to SSI and SIDO data on SSI production for the period 1973/74 to 2004/05 are used for the analysis. The whole period is divided into two: (1) Pre-Liberalization Period (1973/74 to 1989/90), and (2) Liberalization Period (1990/91 to 2004/05). SIDO has revised SSI production and enterprizes data on the basis of the Third All-India Census of SSI units, with effect from 1990/91. We have used the revised data for the liberalization period.

The figures for the growth of bank finance to SSI as well as SSI production and number of enterprizes are presented in Table 6.2. Lending of scheduled commercial banks to SSI has grown more or less in tandem with the growth of SSI production in the pre-liberalization period as well as in the liberalization period, but the growth of entrepreneurship in terms of number of enterprizes was lower than that of production and advances in the pre-liberalization period and much lower in the liberalization period. The growth rate of production also declined considerably in the liberalization period relative to the pre-liberalization period and the growth rate of bank lending to SSI came down likewise. This brings out that the vast policy measures undertaken in the 1990s subsequent to the recommendations of the four

Table 6.2 Growth of SSI, production and bank finance (Rs. billion)

	Bank finance to SSI	SSI production	SSI enterprises (no in million)
Pre-liberalization period			
1973/74	9.04	72	0.42
1989/90	159.69	1323.2	1.82
CARG: 1973/74–1989/90	18.40%	18.68%	9.60%
Liberalization period			
1990/91	179.38	788.02	6.79
2004/05	831.79	4182.63	11.82
CARG: 1990/91–2004/05	10.77%	11.77%	5.10%

Source: RBI (2001); SIDO Online (2006).

Expert Committees mentioned earlier have not made any significant impact in the form of an increased credit flow to SSI entrepreneurs.

This prompted us to probe what kind of relationship exists between annual growth of SSI enterprizes and production with annual growth of SCBs' advances to SSI. We found that there was no significant relationship between annual growth of SSI enterprizes and that of SCBs' advances in the pre-liberalization as well as in the liberalization periods. However, there was a very weak positive correlation (0.07) (which had no statistical significance) in the pre-liberalization period and a statistically significant high positive correlation (0.59) in the liberalization period between annual growth of SSI production and annual growth of SCBs' advances to SSI. This indicates that SCBs' advances to SSI have grown more in tune with the growth of SSI production and not with the growth of SSI enterprizes, particularly in the liberalization period. This could be because in the liberalization period, bank credit might have been directed to "better performers" and indiscriminate distribution of credit might have been the feature of the pre-liberalization period. To probe this issue further, it is appropriate to know how significant bank finance is and what proportion of SSI production is accounted for by the former annually.

The lending of commercial banks to SSI is presented as a percentage of SSI production for pre-liberalization and liberalization periods, in Table 6.3. Lending to SSI varied between 10 and 17% in the pre-liberalization period and between 19 and 25% in the liberalization period. Thus, lending of SCBs to SSI appears to be higher in the liberalization period compared to the pre-liberalization period. This is because of the revision of SSI statistics by DCSSI based on the findings of the Third All-India Census of SSI units with effect from 1990/91. As a result, there was a sudden

Table 6.3 SCBs' lending as a % of SSI production

Pre-liberalization period		Liberalization period	
Year	Percentage (%)	Year	Percentage (%)
1973/74	12.56	1990/91	22.76
1974/75	11.3	1991/92	23.49
1975/76	10.48	1992/93	24.85
1976/77	11.31	1993/94	24.27
1977/78	11.92	1994/95	23.88
1978/79	14.22	1995/96	23.18
1979/80	12.46	1996/97	22.76
1980/81	14.09	1997/98	24.45
1981/82	13.69	1998/99	24.56
1982/83	15.4	1999/00	24.4
1983/84	15.71	2000/01	23.02
1984/85	15.5	2001/02	23.77
1985/86	14.91	2002/03	20.74
1986/87	14.75	2003/04	19.91
1987/88	14.85	2004/05	19.89
1988/89	13.75		
1989/90	12.07		

upward jump in number of SSI enterprizes and employment, but a drastic reduction in the value of production in the SSI sector (Ministry of SSI, 2006). Of course, the variation in the percentage remained more or less the same in both the periods. Similarly, the percentage fluctuated from year to year though declined gradually at the later part of both the periods. In this regard, it is worthwhile to make a reference to the Nayak Committee recommendation. One of the recommendations made by the Nayak Committee was with reference to working capital. The Committee recommended that the SSI sector should obtain 20% of its annual projected turnover by way of working capital. Accordingly, SCBs' should be at least 20% of the output of SSI on annual basis (RBI, 1992).

In the pre-liberalization period, lending of SCBs never crossed the 20% mark. But in the liberalization period, it was consistently above 20% till 2002/03. The share declined gradually since 2001/02 and was less than 20% in 2003/04 and 2004/05. Of course, given the nature of data on SSI production in the two periods, a direct comparison may not be appropriate.

To probe whether there is any linear trend in the share of SCBs' lending in SSI production, we set the linear trend line for the pre-liberalization and liberalization periods separately. The graphical presentation of share of SCBs' lending in SSI production as well as estimated trend lines is given in Figure 6.1. The origin and slope of the two trend lines are presented in Table 6.4. Both the origin and slope of trend lines are statistically significant. What is noteworthy is that, trend line of the lending share had a positive slope in the pre-liberalization period and a negative slope
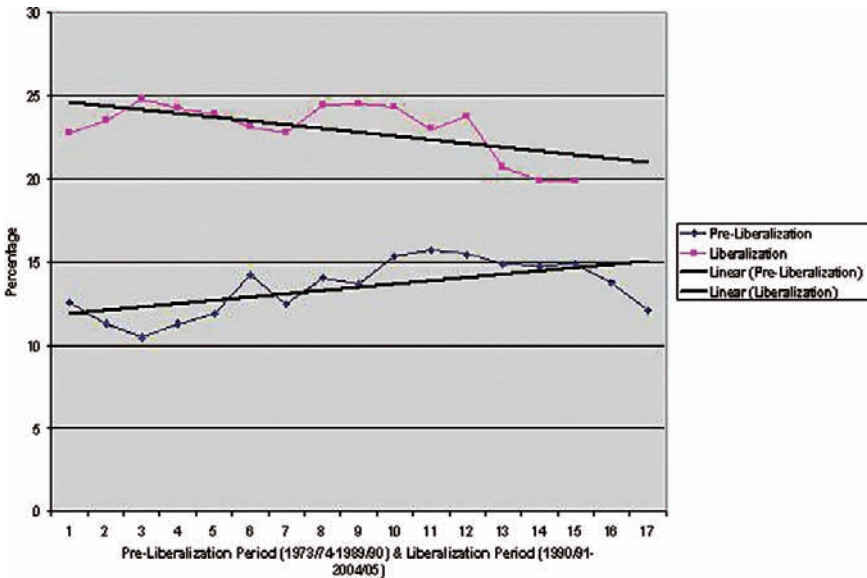
Fig. 6.1 Share of SCBs' lending in SSI production: Pre-liberalization and liberalization periods

Table 6.4 Origin and slope of trend lines for shares of SCBs advances in SSI production

Period	Origin	Slope
Pre-liberalization	11.70 (16.80)*	0.20 (2.90)*
liberalization	24.85 (33.93)*	−0.22 (−2.77)*

Notes: *Significant at 0.05 level.

in the liberalization period. This further lends credence to the argument that SCBs' advances did not grow significantly despite the formulation of exclusive policies and programmes to ease the credit flow to SSI since the early 1990s.

How significant is the influence of SCBs' advances on SSI production is the next pertinent issue? To analyze this issue, we did regression analysis based on the time series data for SSI production and SCBs' advances to SSI for the pre-liberalization period and liberalization period separately. The separate analysis is considered appropriate primarily due to the difference in SSI production data from 1990/91 onwards, as explained earlier. We have taken SSI production as the dependent variable and SCBs' advances to SSI as the explanatory variable. Regression estimation at current prices has its limitations and therefore, we deflated both SSI production data and SCBs' advances by the common GDP deflator and thus used their real values.

The most common problem associated with time-series data is autocorrelation (Ramanathan, 2002). Therefore, we checked all the variables for their order of integration. We found that both SSI production data series and data series of SCBs' advances to SSI in both pre-liberalization and liberalization periods are non-stationary in character due to autocorrelation. We determined the order of integration with the help of a correlogram since neither Augmented Dickey Fuller (ADF) test nor Schmidt Phillips (SP) test could be carried out due to the small number of observations (data points). Based on the stationarity check with the help of a correlogram, production series is treated as $I(2)$ variables and advances series as $I(1)$ variables in both pre-liberalization and liberalization periods. Though our objective is to ascertain the influence of SCBs' advances on SSI production, advances are not the only factor which contribute to SSI production. Since the scope of the study does not include any other determining factor influencing SSI production, we did intervention analysis to get a better estimation of the equation.

A time-series analysis can get affected by a variety of factors such as policy changes, national and international developments, etc. If we overlook these factors, our analysis may not enable us to develop a good model for an appropriate forecast. Such events have been termed as interventions and they can be incorporated into a model by extending it to include deterministic or dummy variables. In a cross-section analysis one can do away with the outliers by excluding them from the analysis, but it is not possible in a time-series analysis. Model specification in the presence of outliers can in principle be carried out using robust methods but an extension of intervention modeling provides a natural means of dealing with outlying observation. Intervention analysis helps to overcome the effect of trend shift

(either increasing or decreasing) or sudden changes or shocks for one particular period of time (pulse shift) in a time series (Mills, 1990). Intervention analysis helps to give a better fit by improving R^2. For the pre-liberalization period, we regressed the first difference of production value on the first difference of SCBs' advances together with statistically significant trend shifts in the year 1984 and 1989, and a statistically significant pulse shift in 1983. Correlogram check of the residual series confirmed it to be integration of the order of I(0). The regression equations are as follows:

Pre-liberalization period:

$$d(PRODPL)_t = a_0 + a_1 T_{84} + a_2 T_{89} + a_3 P_{83} + a_4 d(SCBadPL)_t + U_{at} \qquad (6.1)$$

Liberalization period:

$$d(PRODL)_t = b_0 + b_1 T_{91} + b_2 L_{98} + b_3 d(SCBadL)_t + U_{bt} \qquad (6.2)$$

The results of the regression analysis are presented in Table 6.5. In the pre-liberalization period, SCBs' advances did not have any statistically significant influence on SSI production. The influences of time period T84 and pulse shift P83 are statistically significant. The influence of time period T89 is statistically significant at 10% level of significance. The model is statistically significant as indicated by the F value. The model explains about 85% of the variation in SSI production at the difference level as reflected by the value of R^2.

P83 is negative while T84 is positive, which could be an indication that with the introduction of NABARD in 1982, there could have been an immediate negative impact followed by an increasing trend in the growth of SSI production. NABARD primarily allocated resources more towards agriculture in the rural sector. This could have drained some resources away from SSI, since the common pool of resources to the priority sector remained more or less the same. Increased assistance to agriculture however led to an increased demand for agricultural resources, equipments and others, the supply of which mainly came from SSI, thus stimulating SSI production.

Table 6.5 Influence of SCBs' advances in the pre-liberalization period

Explanatory variables	Dependent variable: SSI production
SCBs advances	1.55 (1.34)
T84	1375.14 (2.49)**
T89	4825.32 (1.84)*
P83	−8357.40 (−2.53)**
Constant	5425.58 (3.45)**
Adjusted R2	0.85
F value	15.12**
Number of observations	16

Notes: *Significant at 0.10 level.
**Significant at 0.05 level.

The question is why SCBs' advances did not influence SSI production significantly in the pre-liberalization period? In the pre-liberalization period, SSI policy was characterized by a variety of protective measures for its growth in the country. These policies comprised a large number of products reserved exclusively for SSI manufacturing, reservation of items for government purchase from SSI, price preference schemes, directed credit flow to SSI under the "priority sector", concession finance, preferential import of capital equipments and raw materials, excise and sales tax exemptions, etc.

In the protective environment, SSI enterprizes would have utilized the "concession" bank finance rather unproductively. Further, if at all its positive influence would have got nullified due to the various protective policy measures of the period. The growth of SSI production could be more due to an increase in the number of units which in turn could be due to protection. The existing SSI units would not have expanded production significantly. This argument gets strengthened when one looks at the composition of SSI units where more than 95% of the units had an individual investment of less than Rs. 0.5 million. In addition, bank finance might have flowed relatively more towards the protected (reserved) segment of SSI. But reserved segment of SSI accounted for a relatively minor share of SSI production and registered a less significant growth (Bala Subrahmanya, 1995). This is because reservation might have induced the entry of new SSI enterprizes and expansion of capacity in existing SSI enterprizes. These enterprizes had higher levels of installed capacities than those manufacturing "unreserved" items, but these enterprizes did not have significantly higher levels of production. Consequently, they had significantly lower levels of capacity utilization (Katrak, 1999). This could be the reason why SCBs' advances did not have a significant influence on SSI production in the pre-liberalization period.

In the liberalization period, apart from SCBs' advances, time period T91 has a statistically significant positive influence on SSI production while level shift L98 has a statistically significant negative influence (Table 6.6). A statistically significant positive trend since 1991 (T91) is an indication of a positive influence of introduction of SIDBI, economic liberalization and introduction of exclusive SSI policy in 1991. On the other hand, the impact of South East Asian crisis is captured by the significant negative level shift of the production of SSI in 1998 (L98).

Table 6.6 Influence of SCBs' advances in the liberalization period

Explanatory variables	Dependent variable: SSI production
SCBs Advances	1.53 (2.72)**
T91	2660.30 (5.05)**
L98	−12040.07 (−2.86)**
Constant	−9356.11 (−3.30)**
Adjusted R2	0.84
F value	18.06**
Number of observations	14

Notes: *Significant at 0.10 level.
**Significant at 0.05 level.

This indicates that though bank finance has not improved significantly in the liberalization period, it has become a crucial factor for SSI performance. This could be because, though the quantum of bank finance relative to SSI production did not improve considerably, it would have met the crucial needs of SSI sector due to the variety of policies and programmes such as establishment of SIDBI and its branches, exclusive SSI branches by Public Sector Banks in SSI concentrated regions across the country, introduction of factoring services, introduction of Laghu Udyami Credit Card, establishment of Small Enterprizes Financial Centers (SEFCs) scheme by RBI, etc. This would have had a significant impact on the quality of credit in meeting the crucial needs of heterogeneous SSI sector. This period has also been characterized by the gradual dilution of protective measures for SSI (Bala Subrahmanya, 2004). This brings out that what is important is not mere protection and increasing the quantity of credit to SSI but a qualitative improvement in the delivery of credit to meet the diverse needs of the SSI sector.

6.4 Conclusions

Meeting the growing credit needs of SSI entrepreneurs adequately has been one of the primary objectives of industrial policy for SSI in India since independence. Accordingly, an extensive financial infrastructure for SSI has been developed over a period of time. Even before the onset of economic liberalization, Indian Policy Makers put in place exclusive financial institutions to meet their long-term as well as short-term credit requirements. However, the pre-liberalization period was marked by bringing SSI under the umbrella of "priority sector" concession finance, among others. In the period of economic liberalization, within a span of a decade, four Expert Committees were set up to look into the problems and needs of SSI including that of finance. Of these, two Expert Committees exclusively dealt with the credit issues of the sector. Based on the recommendations of these Expert Committees, Policy Makers formulated many innovative policies and programmes to cater to the diverse credit needs of the sector.

It is with the above backdrop that the growth of advances of SCBs to SSI is analyzed along with the growth of SSI production and number of SSI enterprizes. The advances of SCBs to SSI grew more or less at the same rate as that of SSI production in the pre-liberalization period but not number of SSI enterprizes. However, there was a significant decline in the growth of SSI production in the liberalization period relative to the pre-liberalization period. Similar to the decline in the growth of SSI production and enterprizes, advances of SCBs came down considerably in the liberalization period. As a result, the growth rate of advances of SCBs has not been significantly different from that of SSI production in the liberalization period as well. But there was no statistically significant relationship between the annual growths of advances and SSI enterprizes in both pre-liberalization and liberalization periods. Similarly there was no statistically significant relationship between annual growths of advances and SSI production in the pre-liberalization period. But in

the liberalization period there has been a statistically significant positive relationship between the two. This substantiates the inference that SCBs' advances grew in tandem with that of SSI production in the liberalization period rather than in the pre-liberalization period despite the declined average growth of the former relative to the earlier period.

SCBs advances as a percentage of SSI production hovered between 10% and 16% in the pre-liberalization period and between 19% and 25% in the liberalization period. The higher share of SCBs' advances in the liberalization period is because of downward revision of SSI production by SIDO based on the findings of Third SSI Census and therefore, cannot be attached much significance. But the trend line for the share of SCBs' advances in SSI production had a positive slope in the pre-liberalization period but a negative slope in the liberalization period. This indicates that SCBs' advances as a percentage of SSI production are on the decline in the liberalization period. This calls for remedial measures from the government. This is because if the same trend continues, it would be detrimental for the performance of SSI in the future. Further, governments can accelerate the development of markets for financial and non-financial services suited to SMEs by promoting innovation in products and delivery mechanisms and by building institutional capacity (Hallberg, 2000).

However what is more prominent is the result of analysis on the influence of SCBs' advances on SSI production. The influence of SCBs' advances was statistically not significant in the pre-liberalization period. In the liberalization period, on the other hand, the influence of SCBs' is positive and statistically significant. In the protection diluting 'competitive environment' of liberalization period, bank finance would have become much more crucial unlike in the past. The qualitative improvement in the credit delivery system due to the introduction of innovative policies and programmes over the 1990s would have resulted in the positive influence of SCBs' advances on SSI production.

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Chapter 7
Demographics and Entrepreneurship: Evidence from Germany and India

Munish Kumar Thakur, Raveendra Chittoor, and Sinnakkrishnan Perumal

7.1 Introduction

There is increasing empirical evidence to suggest that the source of economic growth for many nations is entrepreneurial activity (Audretsch and Fritsch, 2003). However, there is still a strong need for empirical support on the various theoretical factors that are hypothesized to foster entrepreneurial activity. With scholars questioning the applicability and validity of theory in global settings, many national level empirical studies are needed in different geographical and cultural contexts. This chapter attempts to examine the empirical evidence on the impact of three critical demographic factors namely, migration, population structure and higher education on entrepreneurial activity, in the cross-cultural context of Germany and India.

Germany and India have different levels of entrepreneurial activities (Global Entrepreneurship Monitor, 2002). They also share some interesting commonalities and differences in demographics. Some of these commonalities and differences have been associated with entrepreneurship in the literature. These are: migration (Aldrich and Waldinger, 1990; Constant et al., 2004), higher education (Baumol, 2005; Chander and Thangavelu, 2004) and population structure (Wagner and Sternberg, 2004). Hence, it would be interesting to study how these variables have contributed to differences in entrepreneurial activities in the two countries, even though there are many other factors like unemployment, participation of

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female labour force, culture, life satisfaction, research and development etc., that could affect entrepreneurial activity (Ingrid et al., 2006). However, this chapter restricts itself to those demographic variables which highlight the commonalities and differences between Germany and India.

One of the important common threads running across India and Germany is that both are relatively young nations in their present political forms, although both have had centuries of rich cultural history. Germany as a nation has undergone a lot of changes. It has been part of Roman Empire, Austro-Hungarian and Prussian empire. After the Second World War, the country was split into two nations. Recent changes in the geo-political environment of the country include re-unification of Germany after the breaking of Berlin Wall and formation of European Union. Similarly, India as a nation has undergone many changes, historically as well as in recent times. It underwent numerous unifications and divisions before and after British Empire. India was re-unified as a nation during colonial period. Other nations such as Myanmar, Pakistan, Srilanka and Bangladesh were carved out of India's territories. The nation in its present form was created by uniting big provinces and small principalities together after independence. Even within the present geo-political boundaries of nation, there have been continuous divisions with many states split up into two or more states.

The continuous unifications and divisions in the two nations have led to a lot of flux of population within and across borders, especially during these times of transitions. This flux has resulted in important macro trends at social, political and economic level. For example, partition of Bengal led to a sudden upsurge in economic activities in Bengal and so was the case with partition of Punjab. Germany too witnessed a huge increase in economic activities in the post Second World War era.

The second commonality between Germany and India is that both have strong higher education systems. This is quite unexpected as the two countries are at the two extremes on the scale of economic development. Germany enjoys almost a hundred percent literacy while India is struggling with its literacy program with only half of its population being able to read and write. However, amongst those who attend educational institutions, a significant proportion pursues higher education in India. This has been possible by the large number of colleges and universities of higher learning established on Nehruvian ideals. Also, there is an interesting trend of increased emphasis on technical education in India. The number of institutes imparting technical education has increased rapidly with some of them equipped with excellent facilities. Germany also has sound institutions devoted to higher education, especially technical education.

Besides the above commonalities, there are many differences between India and Germany. Demographically, notable among them is the difference between the population structures of the two countries. Indian population structure constitutes a large proportion of youth of less than thirty years of age. In sharp contrast to India, the proportion of elderly people in German population structure is high and increasing. The proportion of people in the working age is decreasing for Germany while it is increasing for India.

Given these commonalities and differences between the two nations, an important question that arises in relation to entrepreneurship is, "What kind of impact do migration, population structure and education have on differential entrepreneurial activities in these countries?" Examining such a research question using state level data that takes into account various contextual factors within a country, instead of country level data, will be a unique attempt. In this paper, we examine the state level data on demographic measures of the 20 states of India and 15 states of Germany and analyze their relationship with entrepreneurial activity in these states. The results indicate a statistically significant and positive relationship between migration and entrepreneurship activity as well as between population structure and entrepreneurship activity. These empirical results gain significance not only due to the study's focus on the across-state context of India and Germany but also due to the focus on within-the-country flux across two countries. The results, though are significant, should be taken as suggestive rather than confirmatory.

The rest of the chapter is organized as follows. The next two sections review the extant literature and develop specific hypotheses related to the impact of different demographic variables on entrepreneurship activity. The following section deals with data sources, operationalization of variables, empirical analysis and results. The last section discusses the implications of the findings for research and practice, and suggests directions for future research.

7.2 Demographics and Entrepreneurship

7.2.1 Migration

At the outset, it is imperative that we clarify the definition of migration. The term migration is used to denote movement of human beings from one geographical locality to another. The locality could be local region, state or nation. In-migration is migration into the region whereas out-migration is migration out of the region. Transitory migration is migration of people for short term and not with the intention of settling in the new region. Table 7.1 below summarizes this.

Table 7.1 Types of migration

Migration	State	Transit	In-migration
			Out migration
		Non-transit	In-migration
			Out migration
	National	Transit	In-migration
			Out migration
		Non-transit	In-migration
			Out migration
	International	Transit	In-migration
			Out migration
		Non-transit	In-migration
			Out migration

Migration has long been associated with entrepreneurship by scholars studying the entrepreneurship phenomenon. Numerous studies have been done to explore the relationship between migration and entrepreneurship (Gershon, 2000; Light and Bhachu, 1993). Modern nations like America, Australia, Canada, Israel and many others were built as a result of the efforts of migrant population. This is largely true for Germany and India as well. Migrants in these two nations have created organizations and generated wealth. In India, the city of Kolkata blossomed because of the merchant community of Marwaris, who migrated from the state of Rajasthan and in the recent years, due to the influx of Bangladeshi migrants. In the city of Delhi, the economic activities were undertaken by migrants from west Punjab, now a part of Pakistan. This is also true for Jew migrants in Germany before the Second World War. Another example of such a success is that of the Punjabis in U.K. (Frederking, 2004). Hence, if entrepreneurship is defined in terms of business activity, then in-migration has been one of the strong co-relates of entrepreneurship.

However, if we look around the world, there have been quite a few exceptions to the positive relationship between in-migration and entrepreneurship. Not all migrant groups have shown entrepreneurial drive in the same capacities. For example, African Americans have not been that successful in carrying out the entrepreneurial activities (Bates, 1996). The conclusion that could be drawn from these studies is that mere migrant status is not enough for a person to become an entrepreneur. There are other factors that influence entrepreneurial activities of the migrants like the strength of migrant network, knowledge sharing among the migrant network, size of network, etc.

Migrant population, especially when it is in minority, is in a disadvantageous position and hence the normal routes of mobility are blocked to this population (Hagen et al., 1962). The migrant population usually has poor education, poor linguistic skills, and lack of understanding of cultural ethos and local knowledge (Barrett and Jones, 1996). Entrepreneurs try to compensate for disadvantages by working hard and long hours leading to the creation of enterprize. Because of the disadvantageous position, the members in the migrant population also develop stronger ties with each other. The ties help in accessing and exploiting the social capital available from the migrant population (Aldrich and Waldinger, 1990). The country of origin provides the migrant population a platform for mutual trust and enforcement of norms. The ties are not only advantageous for identification of opportunities but also for developing opportunities for entrepreneurship. These ties are important source of ideas, opportunities, finance and human resources (Honig, 1998). Hence, the blocked mobility and social capital available are important concepts in the context of migrant entrepreneurship. Organization creation to generate self employment is one of the various ways of mobility available to migrants to establish themselves in the new locality. Given this literature, we test in this chapter, in the context of both Germany and India, the relationship between in-migration and entrepreneurial activity. Hence, we propose:

Hypothesis 1: Keeping other things constant, higher in-migration would lead to higher entrepreneurial activity in various states of the two countries.

As soon as the migrants arrive in a new region, they face blocked mobility and in some cases even hostilities, in the new regions. However, this push usually is not adequate to start entrepreneurial activity which needs knowledge of local conditions. The knowledge could be of market forces, government regulations, demographic structure, customer preferences, culture, etc. Besides familiarity with the local conditions, familiarity with migrant network also takes time, before the migrant network could be exploited for starting a venture. In other words, there is a time lag between the time migrant arrives in a new locality and the time migrant understands the local conditions and migrant network. However, this analysis could not be done because of lack of data.

7.2.2 Education

Education is the institutional way of providing human capabilities. Education helps people in building competencies that could be harnessed for creating successful new ventures. Higher education has special role in enhancement of capabilities. This is especially true of high technology entrepreneurship as most high technology ventures require capabilities that could be developed through institutions of higher learning (Cooper and Bruno, 1977). Based on this, we hypothesize that:

Hypothesis 2: A higher percentage of population receiving higher education would lead to higher entrepreneurial activity in various states of the two countries.

7.2.3 Population Structure

The second demographic indicator that we selected was that of population structure, which is quite different for the two countries. Indian population is younger while the German population is aging. Entrepreneurship as an activity requires considerable amount of energy and this could be provided by young people. In addition, entrepreneurship requires capabilities as well. The capabilities could be built through formal as well as informal ways. Both means of developing capabilities require time. Hence, a person would be able to create an enterprize only after the capabilities have been developed. With the assumption that the development of capabilities through socialization requires a person to be of at least 15 years of age, we hypothesize that:

Hypothesis 3: A higher percentage of population in the range of fifteen to forty-four years would lead to higher entrepreneurial activity in the state.

7.3 Methodology

7.3.1 Data

Data availability and collection pose particular challenges in the context of developing economies such as India. We used secondary sources for collecting all the data for the study. The data on Indian states was collected from the Centre for Monitoring Indian Economy (CMIE), Indian Census conducted by the Union government of India and the websites www.indiastat.com and www.education.nic.in. State-wise data on Germany was collected from www.destatis.de organized by the Federal Statistical Office of Germany and Statistik Regional Ausgabe, 2004. All the data pertain to the period 2003–2004 except the migration data, which was for the year 2001 in the case of India and which was a three-year average (ending 1997) for Germany. Per capita gross domestic product (GDP) data was for the year 2002 in case of India. In all, data for 20 Indian states and 15 German states were considered yielding a total sample size of 35. Berlin and Delhi were excluded as they were found to be outliers. Data on other Indian states were not available.

7.3.2 Measures

All the measures were zero-mean normalized to enable comparison across Indian and German states. The normalized measures highlight variations across the states.

7.3.2.1 Entrepreneurial Activity

We chose entrepreneurial activity, which is a more stable measure compared to rate of entrepreneurship, defined in terms of number of new companies formed every year, given the lack of time-series data (Gartner and Scott, 1995). We define entrepreneurial activity as the number of companies divided by the population of a state as a measure of entrepreneurial activity. The number of companies registered in each of the states as per the Companies' Act of India was used to measure entrepreneurial activity in India, while the total number of enterprizes in each of the German states was used as a comparable measure in the case of Germany. This measure has certain advantages over other measures. First, data is available, i.e., both population data and total number of enterprizes data used for this measure are available. Second, cross country analysis becomes easier. Though, it must be said that this measure is not without its disadvantages (Gartner and Shane, 1995).

7.3.2.2 Migration

Several measures of migration have been used in literature such as in-migration, out-migration, net migration or percentage of foreign-born population in the total

population and so on. To measure the flux created by migration at the state level we used in-migration (sum of domestic and foreign) measured as the proportion of in-migrants to the total population of the state. We were not able to separate transitory migration from the data we have.

7.3.2.3 Population Structure

The percentage of people belonging to the bracket of 15–44 years in the total population of the state was used as a measure of the population structure.

7.3.2.4 Higher Education

The number of people with an education of graduation and above as a percentage of all eligible people was used as a measure of enrolment into higher education in the case of both Indian and German states.

Per capita GDP of the states was included as the control variable. Per capita GDP is found to have a high correlation with all socio-economic factors and hence it is, by itself, assumed to be a sufficient control for all possible confounds.

7.4 Empirical Results

Table 7.2 reports the Pearson correlation coefficients for the sample data. The hypotheses were tested through ordinary least squares (OLS) regression. Entrepreneurial activity was modelled as a function of in-migration, population structure, higher education and per capita GDP. Collinearity diagnostics were performed by examining bivariate correlations and variance inflation factors (VIFs). All required assumptions for regression equations such as independence of errors and normality of the distribution of errors were checked for and were met.

Table 7.2 Pearson correlation coefficient

Pearson correlation coefficient				
Variable	1	2	3	4
1. Entrepreneurial activity[a]				
2. In-migration[a]	0.53***			
3. Higher education[a]	0.29+	0.22		
4. Population structure[a]	0.58***	0.18	0.43**	
5. Per capita GDP[a]	0.56***	0.47**	0.52***	0.47**

Notes: [a]Zero-mean normalized. N = 35. + Significant at 0.10 level.
*Significant at 0.05 level.
**Significant at 0.01 level.
***Significant at 0.001 level.

Table 7.3 OLS regression for both countries combined

Results of OLS regression with entrepreneurial activity as the dependent variable[a]

Variable	β	t	VIF
In-migration[b]	0.37	2.63*	1.29
Higher education[b]	−0.11	−0.73	1.46
Population structure[b]	0.46	3.21**	1.38
Per capita GDP[b]	0.22	1.34	1.87
Number of observations	35		
F	9.30***		
R^2	0.55		
Adjusted R^2	0.49		

Notes: [a]The Table reports standardized coefficients. VIF values indicate no multi-collinearity.
[b]Zero-mean normalized. + Significant at 0.10 level.
*Significant at 0.05 level.
**Significant at 0.01 level.
***Significant at 0.001 level.
All errors and covariances are consistent with White General Heteroscedasticity.

The results of OLS regression estimation are reported in Table 7.3. VIF values for all variables are less than 2 indicating the absence of multi-collinearity. Heteroscedasticity was found in the data, therefore the results obtained were adjusted for heteroscedasticity using White General Heteroscedasticity test. The overall regression equation is statistically significant ($p < .001$). The results provide support to Hypothesis 1 with migration showing positive and significant beta coefficient ($\beta = .37$, $p < .02$). No statistically significant relationship is found between higher education and entrepreneurial activity ($\beta = −.11$, $p < .47$) resulting in a lack of support for Hypothesis 2. Also, we tested for quadratic and cubic relationship between higher education and entrepreneurial activity, but we found insignificant and poor results in these cases as well. However, we found differences in correlation between Germany and India. For Indian states, the correlation was 0.7 and for Germany, it was 0.1. The results provide strong support to Hypothesis 3 with population structure showing positive and significant beta coefficient ($\beta = .46$, $p < .005$).

We realized that estimated parameters may not be same for Indian and German states. In this situation, it is imperative that we do separate analysis for India and Germany. To do so, the data for India and Germany was separated. However, we were confronted with various problems. There was multicollinearity in Indian data. To take care of the multicollinearity, per capita income was removed as a variable. To arrive at consistent results, the variable was also removed from German data. OLS regression was run with entrepreneurial activity as dependent variable and migration, higher education and population structure as independent variables. All results were adjusted for heteroscedasticity by using White General heteroscedasticity tests. The results obtained were different as compared to results obtained by combining the data.

In case of India, the overall model was found to be significant. However, there were some changes at the level of individual variables. Migration and education

Table 7.4 OLS regression for India

Results of OLS regression with entrepreneurial activity as the dependent variable[a]

Variable	β	t	VIF
In-migration[b]	0.16	0.19	2.24
Higher education[b]	0.33	1.79*	2.37
Population structure[b]	0.48	3.47***	1.32
Number of observations	20		
F	11.34***		
R^2	0.68		
Adjusted R^2	0.62		

Notes: [a]The Table reports standardized coefficients. VIF values indicate no multi-collinearity.
[b]Zero-mean normalized. + Significant at 0.10 level.
*Significant at 0.05 level.
**Significant at 0.01 level.
***Significant at 0.001 level.
All errors and covariances are consistent with White General Heteroscedasticity.

Table 7.5 OLS regression for Germany

Results of OLS regression with entrepreneurial activity as the dependent variable[a]

Variable	β	t	VIF
In-migration[b]	0.29	1.10	1.38
Higher education[b]	−0.38	0.25	1.37
Population structure[b]	0.52	3.00**	1.04
Number of observations	35		
F	3.62*		
R^2	0.49		
Adjusted R^2	0.36		

Notes: [a]The Table reports standardized coefficients. VIF values indicate no multi-collinearity.
[b]Zero-mean normalized. + Significant at 0.10 level.
*Significant at 0.05 level.
**Significant at 0.01 level.
***Significant at 0.001 level.
All errors and covariances are consistent with White General Heteroscedasticity.

were not found to be significant at 5%, but education became significant at 10%. Population structure was found to be significantly related to entrepreneurship activity.

In case of Germany, the overall model was found to be significant. Like in case of India, population structure was found to be significantly related to entrepreneurship. This relationship was linear. Variations in migration and education were found to be insignificant. Unlike in case of India, education was not significant even at 10%. The standard errors and co-variances were consistent with White General heteroscedasticity.

7.5 Discussion and Conclusion

This study examined the impact of in-migration, population structure and higher education on the entrepreneurial activity of various states in India and Germany through a unique approach of using state-level data. The statistical analyzes of the secondary pooled and non-pooled data yielded different results with migration and population structure significantly related to entrepreneurship for pooled data while only population structure being significantly related to entrepreneurship when data was analyzed separately for each country. Migration was not found to be significant when analyses were done separately, for both the countries. Education was found to be significant in case of India but not in case of Germany. Hence, it would be difficult to draw any conclusion with respect to migration. But analyses with pooled and individual data prove that younger population is more entrepreneurial in both the countries. This result is consistent with the findings of earlier studies related to age and entrepreneurship. Probably, the role of youth and energy as important for as a motivating factor for combining different resources in creation of enterprises is also vindicated. Education was found to be significant in case of India but not for Germany, suggesting that when the part of population is highly literate and the other part almost illiterate, as is the case with India and not with Germany, there are chances that information asymmetry aids in organization creation. However, this is just a conjecture and has to be proved.

The hypothesis that higher education does not have positive impact on entrepreneurship in Germany could be because information advantage that highly educated population can enjoy over other people may be less in Germany. There could be other reasons for it. Also, this could be due to the fact that separate data related to technological entrepreneurial activity which is likely to be fostered by higher education was not available and hence not considered for analysis. Hence, it may be a good idea to ratify the results in future by taking the percentage of pupils enrolled in tertiary and technical education as the chosen measure. Further, results could change with a bigger sample size.

On the policy front, the study has important implications in terms of fostering entrepreneurship through higher percentage of young population.

We recognize a number of possible limitations to this study and hence the conclusions drawn are only suggestive and by no means definitive. First, the number of data points used for the study is relatively small. The problem of data points was further confounded when data corresponding to the countries were treated separately. We had 20 data points for India and 15 for Germany, which were insufficient. Probably, this could be handled in a future study through district level data rather than state level data. Further, curve between variations and entrepreneurship and variations in higher education was quadratic in case of German data. In future, non-linear regression based on quadratic relationship could be tried with German data. Second, the study is cross-sectional in nature and does not capture the dynamics introduced due to the time factor, which is very important for establishing causality. Third and most importantly, the study uses variations in pooled state level data from two countries and hence ignores the influence of many important country level differences.

Similar studies can be replicated with larger sample of state level data within and across countries. Richer insights could be obtained by using longitudinal studies and factoring in cross-country differences.

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Chapter 8
Comparing Entrepreneurial Climates of Germany and India: More Similarities than Differences?

Jagannadha Pawan Tamvada

8.1 Introduction

In this descriptive empirical study, we attempt a detailed comparison of the entrepreneurial climates of Germany and India. An analysis of the well known Global Entrepreneurship Monitor (GEM) expert questionnaire dataset enables us to identify similarities and differences in the entrepreneurial climates of Germany and India.

Even though empirical as well as theoretical studies continuously debate the nature of entrepreneurship, there is convergence of opinion on its positive role in reducing unemployment and improving economic growth (Carlsson 1992, Carree et al. 2002, Acs and Audretsch 1989a, Audretsch et al. 2002, Audretsch et al. 2006). Empirical results suggest that there are two sets of factors, one at the individual level (Evans and Leighton 1989b) and the other at the regional level (Georgellis and Wall 2000), that determine entrepreneurial activity.

We define the set of regional factors that influence entrepreneurial activity as the entrepreneurial climate of the region. In essence, entrepreneurial climate refers to the constellation of factors that determine entrepreneurial activity at the regional level. Referring to the role of environment, Cole (1968) observed that "the manner in which the entrepreneur or his administrative group performs is—and always has been—shaped by ideas currently dominant in the circumambient society—religious, moral, political." One of the major contributions of this chapter is that it provides a first comparison of entrepreneurial climates of a developed economy and a developing economy. It comes up with a number of similarities in two apparently very different economies. The second contribution is that it provides a unique approach to analyze the GEM expert questionnaires for comparing the entrepreneurial conditions in two countries.

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The following section presents the contextual background. The third section describes the dataset and the methodology. The fourth section presents the empirical results and the final section concludes this chapter.

8.2 Background

Entrepreneurial activity in an economy primarily results from a climate that nurtures entrepreneurial capabilities and promotes entrepreneurial orientation of its people. Though there are studies that extensively analyze the determinants of entrepreneurial activity in developed economies, there are very few studies that examine the case of less developed economies. Existing literature suggests a U shaped relationship between level of economic development and entrepreneurial activity (Wennekers and Thurik 1999, Wennekers et al. 2005).

Individual characteristics and regional characteristics are found to influence entrepreneurial activity. At an individual level, personal characteristics such as age, education level (Evans and Leighton 1989a, Rees and Shaw 1986, Evans and Leighton 1989b), earlier self employment experience (Evans and Leighton 1989b), occupational choice of parents (Blanchflower and Oswald 1998), marital status (Fairlie and Meyer 1996) and psychological factors such as motivation, higher risk tasking propensity, internal locus of control (Miller 1984, Kihlstrom and Laffont 1979, Johnson 1978, Min 1984) determine whether an individual selects self employment. These form a set of personal characteristics of an individual that influence his occupational decision.

At regional level, region specific characteristics such as industry structure (Acs and Audretsch 1989b, White 1982), unemployment rates (Blanchflower 2000, Blanchflower and Oswald 1998), local job layoffs (Storey and Jones 1987) and public policy variables such as state retirement benefits (Blau 1987) and unemployment benefits (Carrasco 1999). Institutional and investment climates also belong to this second set. In the context of entrepreneurship, investment climate refers to the presence of efficient financial markets, venture capitalists, and investors who support new ventures, while institutional climate refers to the legal, political, financial and public institutions that directly or indirectly influence entrepreneurial thinking and risk perception of individuals (World-Bank 2004).

The period between 1989 and 1991 witnessed a critical phase in the political and economic transformations of both India and Germany. The fall of the Berlin wall culminated in the reunification of Germany, and the process of economic liberalization initiated the Indian economy on a broad scale into capitalism. The decade following this period witnessed a structural transformation in their economies that led them through different trajectories of growth.

Referring to the potential that India holds forth now, Dahlman and Utz (2005) write, "India can count on a number of strengths as it transforms itself into a knowledge-based economy: skilled human capital, a democratic government, widespread use of English, macro-economic stability, a dynamic private sector,

institutions that support a free market economy, one of the largest local markets in the world, a well developed financial sector, and a broad and diversified science and technology infrastructure. In addition, development of the ICT sector in recent years has been remarkable." They further state that, "In particular, India should further reform its overall economic and institutional environment, and press on with the economic reform agenda that it put into motion more than a decade ago to accelerate growth."

Basic telephone services and data communications were under the control of Indian government until recently. Private sector companies in India often complain about burdens such as the cost of power, borrowing, red-tape and corruption, local taxes, slow and expensive transport, and inflexible labor markets (Economist 2000). The McKinsey Global Institute examined India's economy to see what was holding it back and which policy changes would accelerate growth, and found three main barriers to faster growth in India: multiplicity of regulations governing product markets, distortions in the market for land and widespread government ownership of businesses (Lodovico et al. 2001).

The results of liberalizing sectors such as telecom, banking, aviation and real estate are now beginning to show (Dahlman and Utz, 2005). According to them, India has great potential for future growth due to some intrinsic advantages like low cost and skilled work force and abundant raw materials, but India's growth is hampered by factors like declining productivity of public sector, low integration into the global economy, limited levels of foreign direct investment, weak infrastructure and an investment climate that has to be strengthened.

In comparison, as the OECD (2005) report on Germany reads, "Growth remains weak and heavily dependent on foreign demand, but both non-residential investment and—somewhat later—household consumption are projected to pick up in the course of 2005." It further states that, "The economy grew by 1.6% in 2004 ending couple of years of stagnation" and "activity stagnated again in the second half of 2004 as domestic demand remained subdued and exports decelerated in a context of slowing world trade and euro application." The OECD (2005) report on Germany indicates none of the optimism that Dahlman and Utz (2005), among others, hold for India.

8.3 Data and Methodology

8.3.1 Data

Each year the GEM team collects cross-country data on entrepreneurship. One of the aims of the GEM team is to have harmonized figures on entrepreneurial activity in different countries that enable cross-country comparison. Two different surveys are conducted in each GEM partner country. The first is the adult population survey and the second is the expert survey. For adult population survey, a sample of adult individuals is selected by the GEM team and interviewed. For the expert surveys,

professionals having expertise in some area are questioned about the entrepreneurial conditions in their economy. Most of the research based on the GEM data primarily relies on the adult population surveys and most of the papers use aggregated estimates of entrepreneurial activity in different countries for cross country comparisons (Wennekers et al. 2005, Wong et al. 2005). However, the expert questionnaires are rarely used for empirical analysis. We use individual responses for our comparative study and not aggregate figures of entrepreneurial activity.

In total 183 surveys were conducted for the years 2000 and 2001. We assess the entrepreneurial climate of Germany and India based on the survey responses of professionals and experts on the different entrepreneurial framework conditions. Questions on these framework conditions are grouped into eight entrepreneurial climate dimensions for a comparative study. The range of the response value of each question is 1–5. A response value 1 indicates strong disagreement and a response value 5 indicates strong agreement.

8.3.2 Methodology

We use a two step non parametric test procedure. In the first step, we test for the similarity of the response distribution for each question in the entrepreneurial climate dimensions using Wilcoxon rank-sum (Mann-Whitney) tests on the hypothesis, $H_0 : Germany = India$. If the Wilcoxon rank-sum tests are significant, we reject the similarity of the response distribution of experts on this question. If we are unable to reject the hypothesis, then we do another test in the second step. We use Wilcoxon-signed rank tests, to test departures from neutral given by a response value 3. This enables us to determine whether on this particular aspect both Germany and India are conducive or against entrepreneurship. If the value of z is significant and positive (negative), then experts in both the countries agree (disagree) on the question.

8.4 Empirical Results

Below, we compare Germany and India on the following entrepreneurial climate dimensions: financial climate, public policy towards new firms and entrepreneurship, entrepreneurship education, new firm's access to technology, business opportunities and entrepreneurial inclinations, infrastructure, entry barriers, social attitudes and entrepreneurial reward systems. The test results for the questions that identify major similarities and differences are given in Tables 8.1 and 8.2. For reasons of brevity, barring few exceptions, we report test results for only those questions that are consistent in both years.

Table 8.1 Summary of major differences (Germany and India)

Climate:	H_0: G = I	Wilcoxon rank-sum			
		2001		2000	
		z	$Prob > |z|$	z	$Prob > |z|$
Financial climate	Venture capitalists support	3.6730	0.0002	5.3490	0.0000
Financial climate	Government subsidizes new firms	2.9130	0.0036	3.0390	0.0024
Public policy	Competent government agencies	2.8790	0.0040	3.4660	0.0005
Public policy	Priority for national government	2.0900	0.0366	2.0340	0.0420
Public policy	Priority for local government	2.7630	0.0057	2.9800	0.0029
Public policy	Many Government programs	6.6890	0.0000	3.9250	0.0001
Public policy	Science parks	5.4740	0.0000	5.2010	0.0000
Education	High Level of business education	−2.3520	0.0187	−3.4410	0.0006
Access technology	Transfer from public research	2.8990	0.0037	1.9580	0.0503
Business opportunities	Easy information on opportunities	3.3430	0.0008	3.3390	0.0008
Business opportunities	Many are experienced in starting new businesses	−4.4910	0.0000	−3.5810	0.0003
Business opportunities	Many react to opportunities	−5.2110	0.0000	−3.0070	0.0026
Infrastructure	Good physical infrastructure	7.3510	0.0000	7.7480	0.0000
Infrastructure	Access to utilities in a month	5.4250	0.0000	5.6600	0.0000
Infrastructure	Communications access cheap	4.3090	0.0000	3.6180	0.0003
Infrastructure	Cost of basic utilities affordable	3.1720	0.0015	3.5110	0.0004

Notes: Results of the first step of the test procedure. H_0 is rejected for all the above variables.

8.4.1 Financial Climate

The major differences in the opinions of experts with respect to financial climate are as follows: firstly, there are more public subsidies for promoting firm creation and firm growth in Germany compared to India, secondly, venture capital markets are perceived to be more active in Germany than in India. However, private individuals other than the founder entrepreneurs are considered to be an important source of private financial support for new firms in both the countries.

8.4.2 Public Policy and Entrepreneurship Programs

The experts in Germany opine that support for new firms has a higher priority at national and local government levels in Germany than the experts in India. Furthermore, the public policy measures for encouraging entrepreneurship are more numerous in Germany. Science parks and business incubators provide greater support for new firms and employees working for government agencies are more competent and effective in their support for new firms in Germany than in India. However, there are some similarities as well. In both the countries, government policies like public procurement are not oriented towards new firms. Taxes pose a heavy burden on new firms. Governmental regulations are not considered to be consistent and predictable in either of the countries.

8.4.3 Basic and Entrepreneurship Education

Strikingly, the experts in India have a stronger belief about the business and management education in India than their counterparts in Germany. In both the countries, teaching at primary and secondary education levels is not considered to be encouraging creativity, self sufficiency and personal initiative. It is also believed that general education neither provides adequate instruction in market economy principles nor adequate attention to entrepreneurship and new firm creation.

8.4.4 Access to Technology

In comparison to India, technology, science and knowledge are believed to be more efficiently transferred from public research centers and universities to new firms in Germany. Furthermore, both have a science and technology base that allows them to support creation of world class new technology based ventures. However, in both the countries, new and growing firms have lesser access to research and technological facilities relative to large established firms.

Table 8.2 Summary of major similarities (Germany and India)

Climate:	H_0: G = I	Wilcoxon signed-rank			
		2001		2000	
		z	$Prob > |z|$	z	$Prob > |z|$
Financial climate	Private financial support	3.2000	0.0014	−0.8590	0.3901
Public policy	Government favors new firms	−5.2500	0.0000	−2.8710	0.0041
Public policy	Taxes no burden	−3.0540	0.0023	−4.3640	0.0000
Public policy	Regulations applied consistent	−2.1770	0.0295	−4.2430	0.0000
Education	Creativity, self-sufficiency	−5.9210	0.0000	−6.3330	0.0000
Education	Market economics	−7.2390	0.0000	−7.2880	0.0000
Education	Attention to entrepreneurship	−7.5840	0.0000	−9.0650	0.0000
Access technology	For new firms	−4.9360	0.0000	−4.8590	0.0000
Access technology	Support for venture creation	2.7080	0.0068	−0.1150	0.9081
Business opportunities	More opportunities than people	2.3570	0.0184	3.3130	0.0009
Business opportunities	Increased in last 5 year	6.7650	0.0000	8.6870	0.0000
Social attitudes	Welfare systems encourage entrepreneurship	−7.2080	0.0000	−7.3330	0.0000
Reward systems	People can get rich by new ventures	3.2070	0.0013	3.3540	0.0008
Reward systems	Stories in media on entrepreneurs	3.3490	0.0008	6.3250	0.0000
Reward systems	New firms only if no jobs	2.4960	0.0126	−2.0120	0.0442

Notes: If the null hypothesis in the first step could not be rejected, the second step tests if experts in both the countries have positive or negative impressions.

8.4.5 Business Opportunities and Entrepreneurship Inclination of People

It is easier to get access to information required to evaluate business opportunities in Germany than in India. With a strong public policy commitment to entrepreneurship, this is very much expected. In Germany very less number of people are opined to have experience in managing a small business and starting a small business. Moreover in the opinion of the experts, people in Germany are not inclined to react quickly to opportunities to start new businesses. On an average, India appears to be better when compared to Germany on entrepreneurial inclination. Experts in both the countries agree that there are more opportunities for entrepreneurship available than people who take advantage of them. They also feel that in the last five years such opportunities have considerably increased.

8.4.6 Infrastructure

Germany is markedly different to India on this dimension. Availability of excellent physical infrastructure makes Germany very conducive to new venture formation. Inexpensive and advanced communication facilities are available and it is possible to obtain these facilities faster in Germany. Moreover, the experts in Germany opine that new firms can normally afford the cost of basic utilities. It is possible for new firms in Germany to get access to utilities like gas, water and electricity in about a month. On the contrary, the experts in India opine that infrastructure is very poor and is not conducive to new firm formation.

8.4.7 Social Attitudes

We find that the social security and welfare systems in both the countries are not conducive to entrepreneurship in the opinion of the experts. These systems do not provide encouragement for people to take initiative and be self sufficient. Younger people believe that they should not depend too heavily on the government. The social attitudes on personal initiative and individualism in Germany and India are remarkably similar.

8.4.8 Entrepreneurial Reward Systems

In both the countries, creation of new ventures is considered an appropriate way to become rich, indicating that these countries are slowly moving away from

inhibitions associated with entrepreneurial intentions. The media often tell stories about successful entrepreneurs. People think that individuals start new firms only if they do not find regular jobs; however, the opinion of experts is not consistent as is seen in Table 8.2.

8.5 Conclusion

A comparison between the entrepreneurial climates of Germany and India leads to many insights. They are very similar in not focusing on entrepreneurship education, in not being able to provide new firms as much access to technology as to large firms, in having social systems that do not promote individualism, high degree of self reliance and entrepreneurial thinking and in having individuals choose entrepreneurship only when they are unemployed. On the positive side, they are also similar when it comes to availability of good accounting and legal services, respecting successful entrepreneurs and having less barriers to entry from existing establishments. The experts opine that business opportunities in the last five years have increased in both the countries but there are more opportunities than people who recognize them.

Though Germany outsmarts India on infrastructure and has a sound public policy towards entrepreneurship, in contrast, people in Germany are considered to have very little entrepreneurial inclination. Major causes of disinclination in Germans for entrepreneurship may be an education system that does not focus on entrepreneurship. The results suggest that on both these aspects India and Germany are very similar to each other. As entrepreneurial activity is essential for economic growth, the opinions of experts suggest that India may need to provide public programs that aid and support new firms. Incentive systems have two sides, one that reward success and one that do not stigmatize failure. It is very essential that in both countries, greater awareness is created so that entrepreneurial failure is not stigmatized.

A major limitation of the study is that the opinions of individuals are used to evaluate the similarities and differences and not actual figures. This is primarily due to our data constraints. Due to this limitation we are not always able to discern the more basic causes that drive the opinions of the experts or quantify the extent of similarity or difference on the entrepreneurial climate dimensions. Further, in this comparative study, we do not empirically focus on the relationship between the entrepreneurial climates and entrepreneurial activity. Future research should address how climate variations are responsible for variations in terms of both entrepreneurial activity and its quality. A second limitation of our study is that the data was collected in the years 2000 and 2001. After 2002, the GEM team did not collect data in India. In the last six years India has become a high growth economy and has witnessed many changes. Future research should also use more recent data for the analysis.

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Part III
Industry Studies

Chapter 9
Venture Capitalist's Role in Choosing Entrepreneurs: A Study of Indian Biotechnology Industry

Vinish Kathuria and Vandita Tewari

9.1 Introduction

The quest for knowledge economy in 1990s, where industries like information technology (IT), biotechnology etc. are in the forefront, has brought the role of venture capital into prominence. Since these industries are "ideas driven," traditional mode of financing is not available to them. Venture capitalists (VCs) play an intermediary role in financial markets to provide funds to firms which otherwise have difficulty in acquiring funds. In the entrepreneurial setting, financial intermediaries such as venture capital fundings (VCFs) have been cited as perhaps the dominant source of selection (Anderson, 1999). VCs affect selection by providing financial resources to cash-hungry firms and by favoring new firms with, or requiring them to adopt, particular strategies, practices or other characteristics so as to convert ideas into products. VCs may also provide management expertise or access to other capabilities that bolster the competitive advantage of firms that they fund (Hellmann and Puri, 2000). Since VCs are perceived to be "informed agents" able to identify particularly promising firms, their investment provides a certification benefit that can enable the firm to obtain other resources (Megginson and Weiss, 1991). Gompers and Lerner (2001) argue that entrepreneurs have long had ideas that require substantial capital to implement but lack the funds to finance these projects themselves. Since knowledge based, innovative and cutting edge technology projects are risky in nature and traditional modes of financing such as banks are not available to them, venture capital has evolved as a response to this felt need. Venture capital thus represents one solution to financing the high risk, potentially

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Table 9.1 Principal concerns of VCs and banks

	Business aspects	Venture capitalists	Banks
1	Market Risk[1]	High	Low
2	Setting of Targets	High	Low
3	Feedback and Involvement	High	Low
4	Agency risk[2]	Low	High

Source: www.armchaireconomist.com/VCpolicyhints.pdf

high-reward projects. There are other differences too between VCs and traditional loan financing by banks. More importantly, VCs are active investors as opposed to banks. VCs concentrate on and also have a comparative advantage in financing small technology oriented high growth companies, where the entrepreneur has superior knowledge about the prospects of further product development and the required efforts to be put in, but has fewer assets, can thus offer only limited collateral. Even, the commercial experience and know-how as possessed by the entrepreneur is limited. Table 9.1 briefly summarizes the differences in business concerns between the formal VCs and banks.

Since banks tend to be "passive" investors, as compared to VCs, the strategies needed to promote and encourage these investment flows are quite different. Ironically, banks lend money to people who have money. Apart from the risk-bearing stand point, another major key distinction relates to the problem of *asymmetric information*. The lack of collateral and a track record make it difficult for new entrepreneurs to obtain bank financing. Moreover, VCs do not simply provide finance but also a whole range of value added services. These include managerial expertise, addressing *informational asymmetries* by extensively scrutinizing and monitoring entrepreneurial projects, among others. Since VCs are exposed to the risk of a company failure, they prefer investing in companies that have the ability to grow rapidly and give higher-than-average returns to compensate for the risk. Once a new firm gets going, the VC monitors its development, establishes key contacts with customers, suppliers and outside professionals who may be hired by the firm. When VCs invest in a business, they become part owners and typically require a seat on the company's board of directors. The high risk of the projects also has a direct bearing on the future of new companies. Successful ones are often sold at an IPO; the less successful, but still viable, at a private trade-sale, whereas part of the investments must be written off completely. The exit decision—when to get out and in which way—is the final consideration on the part of the VC. Thus VCs focus on industry with knowledge base, skill base, having global presence with cutting-edge technology and capital and infrastructure needs. VCs also benefit from sustained growth and profitability of the funded firm, as this is essential to create a premium exit value in a sale or public offering.[3] Emerging markets and industry like IT and biotechnology have these characteristics, thereby attracting over two- thirds of venture capital funding in recent times. Venture capital has been widely studied in the developed countries context, especially the US (see Gompers and Lerner, 2001, for

Table 9.2 VCs action in developing countries compared to developed countries

	VCs action	Approach in developed countries	Approach in developing countries
1	Selection of firms	Financial and accounting information of the firm to initially evaluate the proposal and assess the risk. Geographic proximity is not the key factor.	Such information not available easily. Not reliable also. Other means used such as relationship with the entrepreneur. Proximity a key factor for funding. Firms near to VCs are funded often.
2	Monitoring of funded firms	Govt. plays no role in the funded firms monitoring and structuring. Shares no goals. Strong regulatory body.	Profit motive not profound. Govt. may also have a strong influence on firm goals. Regulatory control weak. Monitoring of firms' activities closely works as a substitute.
3	Value-added services provided	Advice given is often direct.	Advice to be provided diplomatically. Should not be given as an order to hurt ego of the top management in front of others.
4	Exit of VCs	Exit through IPO is common.	IPOs still limited and purchase of firm by a strategic buyer is more prevalent.

Notes: Adapted from Bruton and Ahlstrom (2003, p. 251).

a review of this work). However, the applicability of these studies in other settings, mainly the developing countries, is not only limited but also questionable. This is because of different institutional set up in these countries. Table 9.2 summarizes the key points of departure across two institutional setups with respect to VCs selection, monitoring and guidance to the firms and what exit routes are available to them.

These institutional differences have come to the fore in an interesting study of 36 Chinese VCs and 3 funded firms by Bruton and Ahlstrom (2003). In developed countries, geographic proximity is important but not the sole key factor for VC funding. This is because financial and accounting information about the firms are available in general to the VCs, whereas, in absence of ready availability of financial and accounting information, developing countries VCs fund only those firms that are located nearby (ibid., 242). Exit route through IPO is generally available in developed countries, but in developing countries, the absence of IPO route makes VCs rely more on purchase by a strategic partner. These institutional differences and a recent upsurge in venture capital funding in Asia, where the industry raised investable capital of over US\$ 7.4 billion in 1998 alone implies that there is a need to study VC financing in developing countries context. Thus, an important research question is to see how do VCs select their investments, especially in a developing country setting? In general, young and small firms confront more obstacles

(Stinchcombe, 1965), as they often lack employee commitment, knowledge of their environment, and working relationships with customers and suppliers. Similarly, since they have little operating experience, start-ups frequently operate using immature and unrefined routines. According to Aldrich and Auster (1990), since startups tend to be small, they are unable to withstand a sustained period of poor performance. This implies startups are in greater need for VC funding. The data however, indicates otherwise. For example, in 2004, out of US\$ 820 million invested in India-based companies by VCs, less than 10% went to start-ups (TSJ Media, 2004). This points to the need to see how VCs select investment in start-ups. Thus, this chapter contributes to the literature by looking into VCs investment decision in a developing country setting and investigates whether the criterion differs across the two groups—start-ups and existing firms. The analysis is carried out for firms in Indian biotechnology industry. The organization of the remaining chapter is as follows: Section 9.2 gives a brief review of literature, which traces out what has been done in the past and why there is a need to study the issue. Section 9.3 gives in brief the relevance of biotechnology industry in the Indian context. Section 9.4 talks about the methodology followed by the data and the variables. Section 9.5 deals with the results of the study. The chapter concludes with Section 9.6 giving the avenues for further study.

9.2 Review of Studies

The research looking into VCs' investment decision is scanty. Even a recent article by Gompers and Lerner (2001) summarizing the research on VC industry has identified three important issues falling under a "venture cycle"—fund raising; venture investing cum monitoring and adding value; and lastly exiting with returning capital to investors. The article has not mentioned much about the selection of a firm by VCs.

Most research assumes that VCs are particularly good "scouts" i.e., they are particularly adept at identifying exceptionally promising startup ventures. Studies have also been based on VC's ability to identify pre-investment, i.e., which start-ups are more likely to enjoy superior performance in the future (see for example Chan (1983) and Shepherd et al. (2000)).

Watson et al. (2003) have emphasized the effects of human capital, organizational demography and interpersonal processes on partner evaluations of venture performance as measured by profit and growth. The results support this approach in analyzing venture teams, and the study proposes that this perspective be included in future venture viability assessment.

In regard to the research question, Cassar (2004) has examined the influence of start-up size, asset structure, organization type, growth orientation and owners' characteristics on both the choice and on the magnitude of finance use. The study reveals that the larger the start-up, the greater the proportion of debt, long-term debt, and outside and bank financing in the firm.

Chang (2003) examines how venture capital financing and strategic alliances affect internet start-ups' ability to acquire the resources necessary for growth. The

study finds that three factors positively influencing a start-up's time to IPO are: a) the reputation of participating venture capital firms; b) reputation of the strategic alliance partners; and c) the size of a startup's network of strategic alliances.

A study by Baum and Silverman (2004) investigates whether VCs emphasize picking winners or building them. This is carried out by comparing the effects of start-ups' alliance, intellectual and human capital characteristics on VCs decisions to finance them with the effects of the same characteristics on future startup performance. The findings point to combined roles; VCs finance startups that have strong technology, but are at risk of failure in the short run and so in need of management expertise. The study argues that while making their investment decisions, VCs tend to make a common attribution error overemphasizing startups' human capital.

Study by Jeng and Wells (2000) however looks at the factors influencing VC funding at an aggregate level using data for a sample of 21 countries. The paper considers the relevance of IPOs, gross domestic product (GDP) and market capitalization growth, labor market rigidities, accounting standards, private pension funds, and government programs. The study finds that IPOs are the strongest driver of venture capital investing at aggregate level. On the other hand, the private pension fund levels are a significant determinant over time but not across countries. One of the important findings of the study is that the GDP and market capitalization growth are not significant. The government policies are found to have a strong impact, both by setting the regulatory stage, and by galvanizing investment during downturns. The study also shows that different types of VCF—early or late stage—are affected differently by these factors. In particular, early stage venture capital investing is negatively impacted by labor market rigidities, while later stage is not. IPOs have no effect on early stage VCs investment across countries.

There has not been any study in Indian context that looks into how VCs choose their investment, though there have been few studies dealing with VCs involvement in general (see for example Bowonder and Mani, 2004; Mani, 2006). Bowonder and Mani (2004) present an overview of evolution of venture capital support for innovation in India. An analysis of venture capital funding trend indicates that venture capital has strong linkages with innovation-based clusters. It has been observed that though there are many determinants, the two major elements that contribute to the success of venture capital assisted firms are: providing market linkages and sharpening the business plan. From the firm side, experience of the entrepreneurs and clarity of the market are the factors that reduce the market uncertainty. The present study thus would be the first to answer the question of VCs decision-making criterion in biotechnology industry in India.

9.3 Biotechnology Industry in India – Role and Relevance of VCs

In the absence of an organized venture capital industry until almost 1998 in India, individual investors and Development Financial Institutions have played the role of VCs. Entrepreneurs have largely depended upon private placements, public

offerings and lending by financial institutions. However, of late VC funding is increasing and biotechnology is one of the few industries receiving major chunk of this investment. Biotechnology appears to be the next hi-tech field in which Indian companies can thrive by performing services for researchers for the West.[4] For the first time in seven years, in 2003, biotechnology has become the number one industry with US\$ 873 million investment, displacing software as the leading category. Investments in biotechnology companies in 2003 increased 31% from the previous quarter and 88% from a year ago.[5]

Currently, in India there are nearly 170 companies engaged in biotechnology field and of these around 60 companies are in modern biotechnology.[6] According to a study carried out by the Confederation of Indian Industry (CII) of 52 modern segment biotechnology companies, the total project investment by these companies was over US\$ 100 million in the last decade. Of these 52 companies, 32 (i.e., approx. 62%) were incorporated after 1998, showing the increased interest in the industry. Despite all this, the biotechnology sector still has a minuscule share (<1%) in country's GDP.[7]

However, given the current growth potential and relevance of the sector, it is certainly going to play a key role in India's economy. The industry analysts have projected the consumption of biotechnology products in India at a level of US\$ 4.27 billion by 2010 approximately with a world market share of about 8%. Importantly, the market segment for modern biotechnology products and services is expected to grow at a comparatively higher average annual rate of 35–40%.

The anticipated growth is primarily because India has natural advantages in biotech. The country's diverse flora and fauna along with rich gene pool offer a gold mine of raw information. India has the largest human biodiversity in the world with close to 600 well-defined ethnic groups (Ernst and Young, 2004, p. 27). Also, India's type II diabetic population is nearly 25 million, accounting for 20% of global diabetic population (ibid.: 30), which gives researchers analyzing genetic links to the disease, hence a wealth of material to work on.

A comprehensive report of the funding requirements of the biotechnology industry, prepared jointly by CII and Rabo India, has estimated that the industry will require US\$ 4800–9600 million in the next two to three years in private equity funds at this stage of development. The government too has taken note of the sector's importance and the proposed fund requirement for biotechnology in the 10th Plan has increased by more than ten fold from that of 9th Plan. The figures for the biotechnology sector are more than US\$ 476 million and US\$ 214 million for R&D.[8] Given the sector's needs, much depends on contribution of private sector. It is imperative that without strategic financing for the sector it is difficult to see its growth in the country and to establish India as a global player in the biotechnology industry. This is where the VCs set in.[9] Given India's rich human capital base, many Indian companies can add value to a large number of companies across the globe. These companies however require funds in the range of about US\$ 0.5 million to US\$ 1.5 million. Since 80% of the research is in early stages, bulk of the proposals does not get support from banks; VCs can effectively fill the gap. Despite sector's immense growth potential it is yet to attract any significant VCF. Indian VCs

invested around US$ 5.3 billion till the end of December 2003. This is a mere 3% of the total invested in Asia. Despite the hype surrounding the sector, VCs investments in this sector till date are less than US$ 60 million. Of the 70 VCs operating in India, only 10 focus on biotechnology sector. VCs often look at relatively short-gestation projects, which are difficult to find in the biotechnology space. Most biotechnology activity in India is in the area of bio-generics and R&D services, which are of long gestation in nature.

9.4 Methodology – Model and Data

9.4.1 Model

This study aims to find the factors affecting VCs' decision for funding for the biotechnology industry. To investigate, the study uses a binomial dependent variable, having 0 and 1 as the options. Probit model is a non-linear statistical model that achieves the objective of relating the choice probability to explanatory factors in such a way that the probability remains between [0, 1] interval.

The dependent variable takes the value 1 if the firm is VC funded and 0 otherwise. The explanatory variables are both continuous and discrete which affect the choice of the VC. The coefficients of these variables will indicate whether the variable is positively or negatively affecting the VC funding. The marginal effect as given by the product of the coefficient and the probability density function (pdf) however, would indicate the effect of a change in an explanatory variable in the mean or the expected value of the dependent variable. Since the pdf is always positive, the direction of the marginal effects is same as that of the coefficient (Greene, 2001).

The model in the present case will be:

$$VCF = \alpha + \beta_k x_{ik} + \mu;$$

Where, VCF takes the value 1 if the VC gives funding to a firm and 0 otherwise, α and β_k are unknown parameters, x_k are different variables that may influence VCs investment decision and μ is the residual. Most of the research on VCs' decision making has investigated how VCs assess the prospects of a portfolio company in terms of profitability (e.g. Roure and Keeley, 1990; Shepherd et al., 2000), survival (e.g. Shepherd, 1999) and performance in general (e.g. Zacharakis and Meyer, 2000; Zacharakis and Shepherd, 2001). Tyebjee and Bruno (1984) argue that VCs' investment decisions could be predicted from their perceptions of risk and return. VCs also assess market potential and also the managerial qualifications of the entrepreneur. VCF investments are often in emerging industries; the above perceptions are also influenced by the ability to accumulate new knowledge, which is, in turn, depend upon the existing stock of knowledge (Cohen and Levinthal, 1990). There is less perceived risk in familiar domains than in unfamiliar ones (Sitkin and Pablo, 1992). A review of these studies indicate that while finalizing the venture to finance VCs look

Table 9.3 Trend of VC funded firms in biotechnology industry

No. of funded firms	Year of funding
15	1990
1	1994
1	2001
24	2002
26	2003

Source: Own compilation from different sources.

into the aspects like size, age, profitability, alliances, R&D expenditure, membership of park etc., that reduces the market risk as well as the *information asymmetry*.

Thus the model to be considered for assessing the choice of a VC funding is:

$$VCF = f(Age, Size, Diversification, Alliances, Asset Structure,$$
$$Organizational Characteristics, Member of Park, Patents,$$
$$Management Differences, Awards)$$

A personal meeting with Jumpstartup Funds,[10] Bangalore, an active VC investing in India, highlighted the same variables for their selection firms to fund. Meeting with ICICI ventures,[11] another active VC also reaffirms the use of these variables for deciding on a firm.

The analysis is carried out in two stages. In stage 1, factors affecting choice of VC is found out in general. In stage 2, the firms are divided in two categories - start-up and late-stage firms. The analysis is then carried out to see whether the choice factors differ across the two groups.

An important issue in the analysis is how to define a start-up firm and which year is to be taken for VC funding. The present analysis assumes that a start-up is a firm set up after 2000, and late-stage firm are those set up before 2000.[12] With respect to the selection of year of funding, the data shows that nearly 85% of the VC funding in India has taken place in two years—2002 and 2003 Table 9.3. For analyzing factors affecting choice for the non-VC funded firms, the average of these two years has been taken as against the year of VC funding of funded firms.

9.4.2 Data and Variables

9.4.2.1 Dependent Variable

VC Support

VCF is denoted as a binary variable and it takes the value 1 if VC funding is supplied to a firm and 0 otherwise.

9.4.2.2 Independent Variables

Firm Size

Theoretical reasons why firm size should be related to the capital structure of the firm include economies of scale in lowering *information asymmetries*, transaction costs, market access, and risk exposure. First, smaller firms may find it relatively more costly to resolve informational asymmetries with lenders and financiers. As a result, they would be more inclined towards VCF. Such effects should be more prominent for start-ups as they are generally more information opaque than existing firms (Berger and Udell, 1998). In the present study, the size is calculated as the log of total assets.[13]

Asset Structure

The more tangible and generic the firms' assets are, the greater the firms' liquidation value, which reduces the financial loss incurred by financiers in the event of the firm defaultering (Harris and Raviv, 1991; Titman and Wessles, 1988). Firms with assets of greater liquidation value get easier access to finance and lower costs of financing, leading to these firms acquiring a higher level of debt or outside financing and less reliance on VC funding. A low liquidation but high intangibility (in terms of ideas) makes it ideal for VC funding (Gompers and Lerner, 2001).

The present study calculates the asset structure as current assets/total assets. Total assets and current assets have been taken till t-1 period for VC backed firms, where t is the year of VC funding. For non-VC backed firms, the average of 2002 and 2003 has been taken.

Firm Age

The biotech industry is characterized by network externalities and positive feedback. Therefore, early entrants can assemble a large dedicated customer base, which gives them competitive advantage against new entrants. Thus firm age reflects a kind of first mover's advantages and may have a direct influence on VCs funding. However, for a start-up, this may not have any relevance as all the firms are new. It has been calculated as the difference between the year 2003 and the year of firm's incorporation.

Firm Alliances

Firms' alliances signal potentiality of the firm. Inter-firm alliances have the potential to alter the opportunities and constraints that start-ups face in their early years. Alliances provide myriad advantages primarily associated with the direct or indirect

access to complementary resources (Chung and Lee., 2000) and to knowledge and other assets for which arm's-length ties are inadequate (Williamson, 1991).

Alliances may also confer legitimacy to a firm's operations (Baum and Oliver, 1991, 1992; Miner et al., 1990), which in turn facilitates acquisition of other resources. Alliance advantages are particularly strong when timely access to knowledge or resources is essential (Teece, 1992). Faced with great uncertainty about the quality of firms (i.e., information asymmetry), VCs will rely heavily on the firms' alliances to make judgments about their promise. Studies have shown that in the race for capital, firms capable of attracting alliance partners will outperform comparable start-ups that lack such capabilities. The present study calculates this by considering the total number of alliances the firm has got with either other related company or institute or marketing agency.[14] For the VC backed firms, this data has been collected till t-1 period (i.e., a year before the period of funding). Regarding the non-VC backed firms data has been collected till 2003.[15]

Firm Diversification

Diversification of the firm in other sectors provides it with economies of scale and scope. This should positively affect the VCs' decision to finance the firm as they may find the venture less risky to finance. Funds can be recovered from the other sector of business to maintain liquidity, hence facilitating easy exit. On the other hand, a diversified firm may also experience some interference from the management, thereby negatively affecting the choice. In the present case, if the firm is diversified into other sectors then it has been assigned a dummy 1 and 0 otherwise.

Management Differences

Management differences may also affect both—the likelihood of obtaining venture financing as well as the early rate of growth and survival prospects of a firm. It signifies if a firm is a subsidiary of a bigger group or a joint venture or a merged firm or has been promoted by some bigger group, its influence on VCF may be varied. This could affect both negatively and positively. VCs may not prefer others to interfere in their activities, which may be the case if the firm is under some other group. On the positive note, it can provide liquidity and alliances. A dummy has been assigned for a firm that is independent and 0 otherwise.

Region

The biotech activities in the country are not well spread across the country. The data shows that the activities are concentrated only in North, South and the West regions. Of the total market of Rs. 23,050 million in 2004, South-based companies accounted for nearly 39% of the business done, while West accounted for 32%, and

the North for 29%. The reasons for several companies to be based in a particular region include good support from associations, availability of research institutes[16] for both alliances and for human capital and the presence of leading companies for alliances. This gets favor from the VCF, as a number of transaction and information asymmetries are taken care. In order to see the influence of location, each region is assigned a dummy; if a firm belongs to a particular region 1 and 0 otherwise.

Member of Park

Of late, many Southern states have set up biotech parks. A firm being its member makes it more likely to forge alliance with other firms and enhances knowledge exchange and spillovers. It can avail the opportunity of information flow at a lesser cost. VCs may be interested in such firms, which are in close network with other players. Apart from this, location of large number of firms in a park reduces transaction cost for the VC (Gompers and Lerner, 2001). In the present study, the impact of influence of biotech park membership is seen using a dummy that takes the value 1 if the firm is a member and 0 otherwise.

Sales Turnover and Sales Growth

The turnover of the firm reflects its potential and capability. VCs want to be sure of the fact that they are investing in a firm, which is capable of standing among others and will offer high sales (and hence significant profits). Sales for the VC-backed firms have been collected till time period t (t being the period of VCF). For the non-VC backed firms, it is the average of 2002 and 2003. Many a time, it is the growth potential that may attract VCF. To see this, growth in sales has also been computed and used interchangeably with sales turnover.

Number of Awards

The recognition of a firm in the industry also counts when the question of funding arises. The award-winning firms may have better contacts and alliances with other companies and research institutions. VCs will have no apprehensions of complicated exit, as due to the recognition they may find many others to purchase their share.

Ideally one should have taken number of patents granted to check for their significance in VCs decision-making (Engel and Keilbach, 2007). Many scholars have noted the unique role of patents in biotechnology (e.g. Flingstein, 1996; Lerner, 1995; Powell and Brantley, 1992; Powell et al., 1996). A biotechnology firm with a patent is in a favorable position to obtain complementary assets and skills (Pisano, 1990) and is more likely to obtain VC financing and willing partners to support commercialization activities (Kenney, 1986; Lerner, 1994). Unfortunately, not all firms

release data for their patent applications and approvals. Since we could not collect
data from the patent office, the total number of awards awarded till time period t
(t being the year of VCF) has been used as a proxy. For the non-VC backed firms,
data is collected till 2003. For a start-up, the variable may be inconsequential.

Number of Plants

A firm may have a big set up with many plants spread across the country. The larger
the base they have, the more they will enjoy economies in production. VCs may
look into this factor also for funding the firms. Again, for the VC-backed firms this
is calculated till t (t being the period of VCF) and non-VC backed firm till 2003.
The variable, however, may be correlated with the size.

Organizational Characteristics

Organizational structure of a firm may also influence its current and future prospects.
For example, a public limited firm will have more liability and may not prefer taking
risk compared to a private limited firm, whose liability is low, thus can take greater
risk. On the other hand, a government owned firm may behave differently due to
different objective function. These organizational differences have been captured in
the present study by taking a dummy for a particular structure i.e., public, private or
govt. firm 1 and 0 otherwise.

Profits

With respect to the profits, if a firm seems stable in terms of returns then it is likely
to attract VC support. Profits for the VC-backed firms have been collected till time
period t (t being the period of VCF). For the non-VC backed firms this period has
been taken as average of 2002 and 2003. Alternatively, the growth in profits has been
computed to see the rise in profit level. Firms having consistent profit (i.e., positive
profit) have been assigned a dummy 1 and 0 otherwise.

Thus, the econometric (probit) model used for the study is:

$$
\begin{aligned}
VCF = {}& \alpha + \beta_1 Alliances + \beta_2 Member\ of\ park + \beta_3 Other\ industries \\
& + \beta_4 Plants + \beta_5 Profits + \beta_6 Sales + \beta_7 Region \\
& + \beta_8 Management\ differences + \beta_9 Firm\ diversification \\
& + \beta_{10} Organizational\ characteristics + \beta_{11} Asset\ structure \\
& + \beta_{12} Awards + \beta_{13} Firm\ age + \mu
\end{aligned}
$$

Where VCF = 1 if the VC funds are supplied; and 0 otherwise. It is to be noted
that many of these variables, which have relevance for existing firms, become

meaningless in the case of a start-up. For example, all start-ups will be in the same age bracket, may not have any other plant and patenting is yet to take place. Similarly, it is too early to expect profits from the start-ups and so on. Thus for start-ups, the model needs to be modified accordingly.

$$VCF = \alpha + \beta_{1s}Alliances + \beta_{2s}Member\ of\ park + \beta_{3s}Other\ industries$$
$$+ \beta_{4s}Sales + \beta_{5s}Region + \beta_{6s}Management\ Differences$$
$$+ \beta_{7s}Firm\ diversification + \beta_{8s}Organizational\ characteristics$$
$$+ \beta_{9s}Asset\ structure + \mu$$

Where VCF = 1 if the VC funds are supplied to a start-up; and 0 otherwise.

Data Sources

Using different sources, a list of bio-technology firms is compiled. The list indicates that there are nearly 170 firms in the industry. Many of these firms are not only small in size but also in early stage. A number of data sources such as biotech park directories, personal meetings, company websites, *Capitaline* and other published materials are looked into to see whether the firm is VC funded or not. With respect to exogenous variables, despite searching a number of sources, we could collect information for only 91 firms (of the total 170) since most of the firms are private limited and are not listed anywhere. Of these 91 firms, 42 ($\approx$45%) are VC financed and remaining 49 (i.e., $\approx$55%) are non-VC financed. Among the 42 VC-backed firms only 11 ($\approx$24%) are start-ups, the rest 31 ($\approx$76%) are late-stage firms. Of these 91 firms, 4 are government owned, hence need to be dropped and for two firms some of the variables were on extremes, indicating that these two firms may be outliers. Thus, the final analysis consists of 85 firms belonging to the sector. These 85 firms belong to different segments of biotechnology sectors: agriculture, aquaculture, horticulture, human diagnostics, human therapeutics, human vaccines, forestry, engineering, environmental, food, beverage and fermentation, veterinary and energy.

The data for listed firms is obtained from *Capitaline*—a computer-based database from the Capital Market. The *Capitaline* data comprises the Bombay Stock Exchange listed companies in different sectors. It compiles annual report on a wide range of firm characteristics including sales, profits, R&D[17] activities, plants, patents, organizational characteristics, etc. As mentioned, the firms in biotech industry are mostly private firms; number of other sources were looked into, still the sales, profits and R&D data were not available for all the firms.

Information regarding the awards, diversification of firm has been collected using business magazines, newspapers and company websites. For membership of the park, the data sources are the ICICI knowledge park directory and Genome Valley Directory, company websites among others. Thus, the study looks into the factors affecting VCs decision for 85 biotechnology firms that began operations in India during the 28-year period between 1975 and 2003.

9.4.3 Descriptive Statistics

Tables 9.4 and 9.5 compare the two groups of firms—VC funded and non-VC backed for both categories of firms—start-ups and existing respectively. It can be seen from Table 9.4 that VC backed late-stage firms are mainly based in Andhra Pradesh (AP), whereas, nearly 38% of non-VC backed firms are from Maharashtra (row 2). Same holds for start-ups (row 2, Table 9.5).

Table 9.4 Descriptive statistics for startups

No.	Variables	VC funded	Non-VC funded
1	No. of firms	31	46
2	Location	(**AP-18**, Del-2, GJ-3, KR-2, MH-5, TN-1)	(AP-8, Del-5, GJ-4, KR-5, MP-3, **MH-16**, TN-2, UP-1, WB-3)
3	Avg. sales	183*	40
4	Avg. profits	55*	1.7
5	Age	18.4	14
6	Range of age	6 to 60	8 to 43
7	Biotech park/ association/member	27	3
8	Org. characteristics	(Pvt.-3, Pub.-26, Govt.-3)	(Pvt.-3, Pub.-42, Govt.-1)
9	Alliances	251*	56
10	Type of alliances	(Ind.-62, Comp.-120, Mkt.-35)	(Ind.-13, Comp.-23, Mkt.-20)
11	Asset structure	0.43	0.45
12	Range of Asset structure	0.01 to 2.8	0 to 2.2

Notes: AP-Andhra Pradesh, Del-Delhi, GJ-Gujarat, KR-Karnataka, MH-Maharashtra, MP-Madhya Pradesh, TN-Tamil Nadu, UP- Uttar Pradesh, WB-West Bengal, Pvt.-Private, Pub- Public, Govt.- Government, Ind.- Industry, Comp- Company, Mkt- Market. * - difference with respect to other group is statistically significant at 5% level.

Table 9.5 Descriptive statistics for late-stage/existing firms

No.	Variables	VC funded	Non-VC funded
1	No. of firms	11	3
2	Location	(KR-5, AP-5, TN-1)	(MH-2, AP-1)
3	Avg. sales	25*	1.74
4	Avg. profits	0.014	0.12
5	Avg. age	3	3
6	Range of age	0 to 5	1 to 4
7	Biotech park/ association/member	6	1
8	Org. characteristics	Pvt.-4, Pub.-7, Govt.-0)	Pvt.-1, Pub.-2, Govt.-0)
9	Alliances	59*	6
10	Type of alliances	(Ind.-21, Comp.-29, Mkt.-9)	(Ind.-2, Comp.-0, Mkt.-4)
11	Asset structure	0.42	0.31
12	Range of asset structure	0.01 to 0.94	0.1 to 0.6

Notes: Same as Table 9.4.

The average sales for the VC funded firms are much higher than those non-VC backed. Similar pattern can be seen with respect to profits. Average profits of VC backed firms are much higher in case of late-stage firms than those of non-VC backed. Start-ups (Table 9.5) are not in a condition to earn huge profits in initial years. Hence not much of significant difference between the average profits of VC backed and non-VC backed startups (row 4). It is clearly seen that VCs prefer firms with more alliances. There are 251 alliances of the VC backed firms compared to 54 of non-VC backed (row 9). The former also seems more liquid in terms of their asset structure (row 11).

9.5 Results and Interpretations

This section gives the empirical results obtained by using Probit framework. The analysis has been performed in two stages—in stage 1 for all the firms and in stage 2 for two categories of firms separately.

9.5.1 Result – All Firms

In the first stage, analysis is carried out on all the 85 firms of both categories—start-ups and late-stage firms. Since data consists of firms of different size, heteroscedasticity cannot be ruled out. The test statistics show the presence of heteroscedasticity. Table 9.6 gives the results for heteroscedasticity corrected model. Column 3 gives the marginal effect. Sales figures show high correlation with profits. Hence both could not be included together in the analysis.

Table 9.6 Factors affecting the probability of choosing a firm for VC funding

No.	Variables	Coefficient value	Marginal effects
1	Private	−0.61 (0.62)	−0.22
2	Independent	−0.51 (0.46)	−0.2
3	Age of firm	0.04* (0.02)	0.02
4	Alliances companies	1.46* (0.47)	0.53
5	Profits positive	0.77* (0.43)	0.3
6	Member of park	2.46* (0.64)	0.78
7	Asset Structure	−0.2013	−0.24
8	Other Industries	−0.6726	−0.44
9	Constant	**−0.58**	
	LR	67	
	R square	0.56	

Notes: Values in parenthesis are standard errors; *indicates variable is significant at minimum 10% level. N = 85.

Table 9.7 Contingency table (N = 85)

		Predicted values	
		0	1
Actual Values	0	38 (86%)	6 (13%)
	1	7 (17%)	34 (83%)

It can be seen from the table that VCs don't prefer a diversified firm, as indicated by the significance of the variable (row 8). One probable reason could be that this divides the funds leaving the firm with less liquidity but also increases chances of managerial interference. The results though not reported, the number of plants and awards don't seem to have any affect on VC funding decision as indicated by their significance levels. Sign and significance level of Private variable (Row 1) indicates that VCs are not concerned with the fact that firm is public limited or private limited. They look into ideas, and whichever suits them they finance that particular firm. The results indicate that assets structure has a significant but negative relationship with VC funding (row 7). Since high asset structure means firm is already liquid, it has less desire for VC funding, this is getting reflected in the sign and significance of the variable. Results show that the probability of receiving VC funding is positive if a firm is a member of a park (row 6) and has alliances with other companies (row 4). This may be reducing information asymmetry. From the marginal effect, it can be inferred that for every 1% increase in biotech membership and forging an alliance, the chances of getting VC funding increases by 0.78 and 0.53% respectively. The model seems to have predicted quite well as indicated by the contingency table (Table 9.7). The table indicates that 86% of the predictions for non-VC backed firms have been made correctly, whereas 83% of the predictions are correct for the VC backed firms.

9.5.2 Late-Stage/Existing Firm Level

The above analysis is carried out on both categories of firms—start-ups and late-stage firms. However, as mentioned, some of the variables like profits, age may have less relevance in influencing VCs choice decisions for start-ups. Thus, in order to see how VCs choice decision is affected by type of firms, the analysis is repeated for both categories of firms separately. Since the sample had only 13 start-ups, a separate analysis could not be carried out for them. Thus the second stage analysis is conducted on 72 late-stage firms only. Table 9.8 reports the results for the heteroscedasticity corrected model. Here also sales figure show high correlation with profits. Hence, both together could not be introduced together.

Results indicate that VCs don't prefer a firm when it is diversified into other sectors (row 6). Diversification may induce management interference and reduce

Table 9.8 Factors affecting the probability of choosing a late stage firm for VC funding

No.	Variables	Coefficient value	Marginal effects
1	Independent	−0.41 (0.52)	−0.15
2	Alliances companies	1.55* (0.56)	0.52
3	Profits positive	1.02* (0.51)	0.33
4	Member of park	1.98* (0.63)	0.64
5	Asset structure avg. 2	−0.72* (0.43)	−0.25
6	Other industries	−1.29* (0.66)	−0.44
7	Constant	(0.58)	
	LR	50.04	
	R square	0.54	

Note: Same as Table 9.6. Age was also there but it did not come out to be significant, hence not reported. N = 72.

Table 9.9 Contingency table (N = 72)

		Predicted values	
		0	1
Actual Values	0	37 (90%)	4 (10%)
	1	6 (19%)	25 (81%)

the liquidity in case the other sector is not profitable. The number of plants and awards, however, don't show significant results for VC funding decision as found earlier.

For this analysis the study uses average of asset structure for 2 years. This could not be used in the previous analysis for all the firms, as the data for startups is not available for all the years. The variable shows a negative relationship with VC funding (row 5) indicating VCs preference for firm, which cannot tap other sources. VCs decision is not influenced by the age of the firm. As after a certain threshold this age factor may not count. It is only in the initial years that this seems to have any relevance. Similarly, the insignificance of "Independent" variable (row 1) could be due to the fact that organization structure may not matter much if all other criteria perceived important have an impact.

Results also indicate that VC funding is directed towards a firm, which is a member of a park and has alliances with other companies (rows 2 and 4). The model seems to have predicted quite well as indicated by the contingency table (Table 9.9). Ninety per cent of the predictions for non-VC backed firms have been made correctly, whereas 81% of the predictions are correct for the VC backed firms.

A comparison of Tables 9.6 and 9.8 indicates that there are factors such as firm type and age which are not relevant for VCs decision to fund an existing firm. However, some of the factors like asset structure, member of the park, profitability etc. are important factors considered by a VC when they intend to support an existing firm.

9.6 Conclusions and Policy Implications

In the light of recent quest for knowledge economy, the role of VCs as financial intermediaries has again become prominent. Although the influence of VCs on selection among firms has been extensively studied in developed countries, little or no research has been carried out in developing countries including India. This chapter fills the gap. Based on an analysis of 85 biotechnology firms, this chapter looks into factors influencing VCs decision to fund a project. The results indicate that VCs look for a firm, which is a member of a park, is not diversified into other sectors, has profitable growth, maintains liquidity and enjoys alliances with other companies.

The study has important policy implications. From the firms' point of view, the results induce a firm looking for VC funding for ideas and finance can shape up itself in the manner suitable to attract VC funding. Besides getting funding, VCs support puts the firm on higher growth path as has been found by a study by Kathuria and Tewari (2004). On an overall perspective, VC funding for biotechnology firms can increase substantially if firms starts offering what VCs look for.

From the government's point of view, given the relevance of biotechnology industry and the inability of the government to provide funds to all the firms, DBT should act as facilitator for forging alliances so that the firms can attract VCs. Setting up biotechnology parks in different states would lead to more VC funding.

The study suffers from a number of limitations. Firstly, the study could not analyze the VCs choice for start-ups due to inadequate degrees of freedom. Similarly, non-availability of data restricted the analysis to only 85 of the total 170 firms. Secondly, the impact of availability of human capital on VCs decision could not be considered for the analysis due to non-availability of data.

Thirdly, R&D performed (and patents registered) by the firm also had to be left out from the analysis due to lack of data. Other studies show that high R&D expenses may both increase the likelihood of financing as well as step up the pace of growth (see for example Eisenhardt and Schoonhoven, 1990).

Lastly, at present in India, different types of VCs are functioning—public, private and foreign, it will be an interesting extension to see whether ownership dictates VCs choice criterion. This study focuses only on biotechnology industry and can be further extended into other high technology sectors, like IT and telecommunications.

Notes

[1]Market risk is exposure to the uncertain market value of a portfolio/commodity. A trader holds a portfolio of commodity forwards. The trader knows what its market value is today, but is uncertain about its market value a week from today. This is called as the market risk.

[2]The possibility of something happening in an organization that impacts on its objectives is called as agency risk. It is the chance to either earn profit or make a loss.

[3]In this context it is important to note that exiting has often proven problematic for VCs in many countries due to host country regulations on securities markets, and divergent disclosure and accounting standards (Peng, 2000).

[4]Source: Nature Biotechnology, University of Toronto (http://www.nature.com/nbt/supplements/index.html accessed on 17.01.2005).

[5]Source: India Biotechnology compiled by Swiss Business Hub India (2003).

[6]Modern Biotechnology consists of medicine (biopharma), fuel production (biofuels), farming and food preparation (bioagri), forensics, environment (bioservices) and improvement of nutritional value, flavour, texture and the shelf life of fermented foods (bioindustrial).

[7]Source: Same as 4.

[8]1 US$ ≈ 45 INR as on April 2006.

[9]Gompers and Lerner (2001) define VC firms as independent, professionally managed pools of equity capital invested in high growth companies. VC firms are typically created on the basis of funds raised from banks, pension funds, businesses and private individuals and that are invested over a limited time span of about ten years on average. VCs eventually exit the companies they invest in.

[10]Jumpstartup, a US based VC, entered India in 2000 At the time of entry, it was a privately managed US$ 45 million firm styled along the lines of Silicon Valley VC firm (The Hindu, 2000).

[11]ICICI ventures is another dominant VC predominantly investing in Biotechnology and have even set up a Biotechnology park in Hyderabad, Genome Valley.

[12]The criterion is not abrupt. The discussion with Jumpstartup also yielded that a firm having started operations in the past 3–4 years will be termed as a start-up.

[13]Since industry consists of firms of different sizes, taking log would reduce the heterogeneity with respect to size and will correct for heteroscedasticity problem also.

[14]The data for alliances have been captured in three different forms—the company-alliances, which shows the number of other companies this firm has alliances with; the institute-alliances highlighting the number of R&D institutes the firm has collaborated for further research; and marketing-alliances, the alliances with the marketing agencies for marketing its products. It is to be noted that marketing alliances will have less relevance for a start-up.

[15]Industry alliances are used as a proxy for R&D due to non-availability of data. The relation works like this—a firm performing more R&D will be able to enter into alliance much faster.

[16]Of the 18 important national research laboratories for life sciences research, 8 are located in two Southern cities only—Hyderabad (5) and Bangalore (3). Similarly, of the three important bio-clusters for networking—two are in South India—one each in Hyderabad and Bangalore.

[17]In place of R&D expenditure, one could use patents data, which as mentioned, are a strong driver for VC selection (see for example, e.g. Engel and Keilbach, 2007; Flingstein, 1996; Lerner, 1995; Powell and Brantley, 1992; Powell et al., 1996). Since we did not have access to the data, we could not use it.

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Chapter 10
Public R&D Policy: The Right Turns of the Wrong Screw? The Case of the German Biotechnology Industry

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10.1 Introduction

The biotechnology industry still has considerable expectations concerning its growth rates in employment, new products, patents and profits. The technology is most relevant for policy makers to foster the national competitiveness, employment and social wealth. It is of particular importance for pharmaceutical companies to develop new products and its future profit margin is promising for private investors. Biotechnology start-ups have received special attention to investors and policy makers in most OECD countries. Actually, industrialized countries invest a high amount of tax payers' money in laboratories, incubators and R&D projects. The common intention is to support biotechnology entrepreneurs and to ensure future competitiveness.

However, it is largely recognized that Germany one of the largest European economies missed the accession of this upcoming key technology in the 1980s, while it evolved in other countries directed by the US. Today, German R&D policy invests a great deal of money each year by funding private business projects, to catch up with leading countries like the UK, the US or Asian competitors in this field. We assume that too many technologies and its increasing complexity overtax policy makers as much as their staff to follow their own strategies. In this chapter we analyze if R&D policy in private business, respective public funding in biotechnology lost its origins, its mission and in the end its power. Our main hypothesis is, that R&D policy and one of its most important policy tools, the R&D project funding failed in the German biotechnology industry. While more and more administration

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is necessary to control R&D funds to steer technologies, and while more and more firms participate in R&D-funding, the whole system is getting inefficient. It is assumed that authorities and public funding agencies neglect to discriminate 'risk' as most important triggers for public R&D funding; it becomes arbitrary.

We assume that public R&D funding degenerates in a public policy without discriminating between firms which suffer from financial risk, technical risk or market risk. Today, and especially in biotechnology, every firm which likes to be funded will be funded, because the R&D policy does not care for different risks any longer. Bureaucrats and experts decide on their own which projects and firms will be funded and become totally screwed on the target population. First, we give a brief overview of the status quo of biotechnology in Germany. In the second section, we review the literature on market failure and R&D policy instruments to foster biotechnology. In the empirical section we describe the data, the econometrics applied and finally, we present the results for Germany. Our main question focuses on which factors determine public R&D funding in the biotechnology industry in Germany and if R&D policy is a steering policy tool towards new technologies or just another kind of industrial policy.

10.2 The Need to Foster Technology

The mechanisms behind the utilization of science and technology fostering economic wealth is eclectic and quite complex, but it is common sense that a lot of scientific results play a fundamental role in advanced modern economies. The technology and its resulting innovation are closely connected with the expectations of benefits to society and economic growth. The success of turning hope towards reality is rather associated with investments of a firms' R&D activity. Unfortunately, the participants of the private sector will only consider their own particular benefits as well as choosing their own level of commitment to the innovation process i.e. R&D investments. As a result of this, market failure could occur, mainly characterized by indivisibilities and monopoly, uncertainty and externalities.

The bulk of analysis by academics on government support for technology development has focused on the issue on social returns. Traditionally it is justified on the grounds that the social returns to research are likely to significantly exceed private returns, and thus that the private sector will under invest in research relative to the social optimum. Arrow (1963) proposes his view that, "when the market fails to achieve an optimal state, society will, to some extend at least, recognize the gap, and non-market social institutions will arise attempting to bridge it". Spence (1984) established this kind of market failure by the issues of appropriation and diffusion of knowledge as crucial characterizing R&D activities: (i) the existence of spillover effects makes it difficult for investors to capture the full social benefits of their innovation and (ii) leading firms charge too much for their new knowledge, such that the diffusion of knowledge is less than the social optimum. Thus, there is a trade-off between incentives for the socially efficient production of new knowledge and the

incentives for its socially efficient diffusion. In this respect economists argue that it is economically desirable to overcome the gap of private costs and social benefits by a financial back up provided by public authorities.

Public incentives to private business R&D are generally preferred to regulations because incentives aim to induce behaviour rather than command it. Subsidies and tax credits are market-compatible forms of direct government intervention and broadly used by policy.[1] In recent years government has committed funds for stimulating business performed research to reduce costs caused by uncertainties and risks as much as fostering knowledge diffusion. Governments use different R&D policy instruments to overcome market failures such as a lack of appropriation by regulation (patent law), a lack of know-how diffusion by incentives to co-operate (exchange of R&D staff, collaborative R&D activities) and a lack of risks by financial incentives such as tax credits or R&D project grants. In general, these policy tools are aimed at correcting for externalities in particular markets and to enhance efficiency. Among most OECD countries government agencies intend to bridge these gaps concerning appropriation, diffusion and technical and market risks by similar justification of public R&D policies:

1. In the US for instance, the Advanced Technology Program (ATP) illustrates these policy rationales, because "it provides cost-shared funding to industry for fledgling technologies that are *high risk* in nature but which could lead to positive spillovers". It "seeks to fund R&D where the resulting knowledge and technologies are fully appropriable; that is investors cannot fully capture the financial returns to their investment. Instead the benefits flow to other firms, industries, consumers and the general public" (NIST, 2004).
2. The European Commission argues that businesses have difficulties to incorporate technologies which are not part of their traditional field of activity and to access new types of skills. In particular, "*financial risks* are seen high for innovation and profitability may be delayed by development hitches and tax may not be neutral between success and failure." This calls for "general measures to streamline innovation processes and direct action on specific market failures" (European Commission, 2004).
3. The German Federal Government justifies its public R&D funding in industry by "external effects, i.e. if third parties can use research results and thus gain an economic advantage without paying the technology developer a fee. In such cases the incentives may be too weak for innovative companies to develop private R&D activities in these areas to the extent desirable if economic profitability considerations were included." Public policy offer R&D funds "where R&D projects have long time horizons, a *high economic risk* and great financial needs and therefore are beyond the possibilities of individual companies" (BMBF, 1993).

Do government agencies bridge these gaps, taking into account different 'risks' by funding firms which suffer from financial, technical or market risk? In the last decade several new technologies such as information and communication technologies, biotechnology or nanotechnology make great progress and governments invests extensive amounts to foster these technologies. However, it is less clear

if governments and its R&D policy addresses the projects and entrepreneurs they aimed to address in the sense of eliminating market failure—or if governments just tend to surf on attraction and public attention to win elections (confer Downs, 1957). The following analysis of missions of the German biotech policy in the field of publicly funded R&D projects is of particular interest because the German industry was pretty late in this technology. Even so, we recognise significant numbers of biotech start-ups and simultaneous significant new public R&D policy schemes since the mid 1990s. We investigate if R&D policy and government funding agencies in such a dynamic environment still follow their basic principles of justification for market intervention, or if R&D policy tends to follow general expectations of public attention and lobbyists.

10.3 Institutional and Historical Background

The origins of biotechnology in terms of a publicly funded scientific discipline are closely related to the origin of penicillin during World War II (Perlman, 1975). After the effect of penicillin has been discovered by *Fleming* in his laboratory in 1928, it becomes obvious that this medicine was of particular importance for society's medical care, workforce and productivity. The British and the US government were the first which funded research in this area since the 1930s but did not achieve large scaled industrial production until the outbreak of the war. Finally, the United States succeeded in the industrial production of penicillin by large R&D subsidies for scientific efforts. At the end of the 1940s, the term "Biochemical Engineering" was created mainly in Anglo-Saxon countries and Japan who become world leaders in the new so called fermentation industry (antibiotics, enzymes), while Europe was a leading player in traditional biotechnological products, such as beer and wine. In Germany the new fermentation technology was imported in the 1950s where the US gave licences to the German chemical and pharmaceutical industry.[2] After the epoch making discovery of the DNA[3] by Crick and Watson in 1953 followed by the innovation of the recombinant DNA technique developed by Boyer and Cohen in 1973, the foundation stone of the biotechnology industry was set. Even the recombinant DNA method which means to have the possibility to produce hybrid gene material by joining pieces of DNA from different organisms and then inserting this hybrid material into a host cell offered a lot of opportunities for business ideas and their commercialization (Orsenigo, 1989). The crucial factor was the possibility to manipulate, create and reconstruct life. Based on technologies derived from the latest results in molecular biology, genetics, biochemistry, informatics or physics, the development of new therapeutics or diagnostics ("red" biotechnology), new products or services for the agricultural and food markets ("green" biotechnology) or for environmental activities ("grey" biotechnology) frame this industry. The value chain within the biotechnology industry contains further services and supplying activities. However, German industry i.e. the chemical and the pharmaceutical sector, was reserved towards biotechnology until the end of the 1960s and as far as innovation

is concerned it behaves like a follower instead of a pioneer. The motive of behaving like this is determined by firms' research strategy which was based on organic chemistry that time. This strategy was in the 1950s and 1960s the road to success for the German industry (Peter, 2001).

The change towards biotechnological research strategies in German R&D departments came quite late. In the 1960s, R&D policy and the conviction to set future trends become more and more important in Europe. The OECD (1966) stated, that "the traditional mix of market mechanisms and policy intervention is less suitable to overcome the complexity of technologies in industrial societies". In this period the German Government decided to push science and research within a proactive R&D policy which has to tackle problems of the next 20 years (Bundesministerium für Bildung und Wissenschaft (BMBW), 1971; Bundesmnisterium für Forschung und Technologie (BMFT), 1972). The issue of biological and medical technologies first appeared in Germany in the public policy scheme called 'New Technologies' in 1968 (Bundesministerium für Wissenschaftliche Forschung (BMWF), 1969). In this context the first large scaled and publicly funded projects started in three companies in Germany.[4] In 1971, the framework programme 'Biology, Medicine and Technology' was initiated to foster science and to stimulate private business. Subordinated funding schemes were designed to offer direct R&D project grants to science and industry. The typical characteristic of this kind of funding is the direct financial support in a concrete field of research. Until today, such grants to the German high-tech industries are given as matching grants, i.e. firms have to contribute a minimum of 50% R&D capital to the publicly funded projects. In the early 1970s, R&D on the structure and function of proteins (proteomics) was publicly funded by the German government as much as resources derived from organic matter (biomass) and sustainable bio production. In the 1980s, the direct project funding of biotechnological R&D was widened by programmes searching for substitutes for animal experiments and by research scholar-partnerships to improve know-how.

At the end of the 1980s, firms wind down their R&D activities in biotechnology because legal restrictions on R&D were widely discussed and restrain research intensive firms from further investments in Germany. The period of the German unification was marked by high uncertainties in different economic respects. Large companies had to think about investments strategies and the future legal framework conditions were less clear. Germany in particular was also marked by a less developed biotechnology sector at the beginning of the 1990s. The awareness of the importance of biotechnology as a key technology combined with the possibility of gaining commercial products did not become a real topic in Germany for a long time (Wörner et al., 2000).

For a quite long time there was no adequate legal framework concerning the requirements of the use of biotechnology. The provisions of national genetic law were first set in 1990. Furthermore, the mistrust of the positive effects of biotechnology was caused by the negative association with genetic manipulation within the public opinion (Harding, 2003). Legal restrictions on R&D, like the first Genetic Engineering Act from 1990, set up barriers causing a negative effect not only for the biotechnology industry as well as for the pharmaceutical industry. As a result

pharmaceutical companies with German headquarters relocated R&D facilities to biotechnological centers outside of Germany.[5] The political climate and public opinion was not in favor of pharmaceutical biotechnology either (Giesecke, 2000; Herstatt et al., 2004; Wink, 2004). However, the amendment of the law on Genetic Engineering in 1993 and gradually increasing economic activity changed the downward trend; about nine important biotech schemes, including Nanobiotechnology and Biological Safety Research characterize the public funding priorities in the 1990s and achieved its peak in numbers of R&D funding programmes, R&D funding amounts and companies at the beginning of 2001. In this boom period of biotech enterprises, 15 different R&D funding programmes do not just reflect policy maker's expectations concerning jobs and welfare but also investor's hope on profits in this technology. Figure 10.1 shows the different R&D programmes and in each case the amount of the funding progression. The distinctiveness of this industry is characterized by some special conditions. Newly created biotech firms carrying out research and development projects face financial problems that are typical for young innovative companies. One specificity of the biotechnology sector is the high level of financing that is required over a long period of time to carry out R&D projects. As a matter of fact, development costs for a new drug—from biological target identification to authorization to commercialization—amount to more than 600 million US dollars and more than ten years (Di Masi et al., 2003; Ollig, 2001). The general change in R&D funding priorities concerning biotechnology can be observed in the mid 1990s, closely related to the so called 'BioRegio competition' (Dohse, 2000).[6] This funding concept aimed at developing a new holistic approach for research and technology policy and was planned to integrate biotechnological capacities and scientific, economic and administrative activities. The governmental purpose of funding biotechnology was—and still is—to ensure
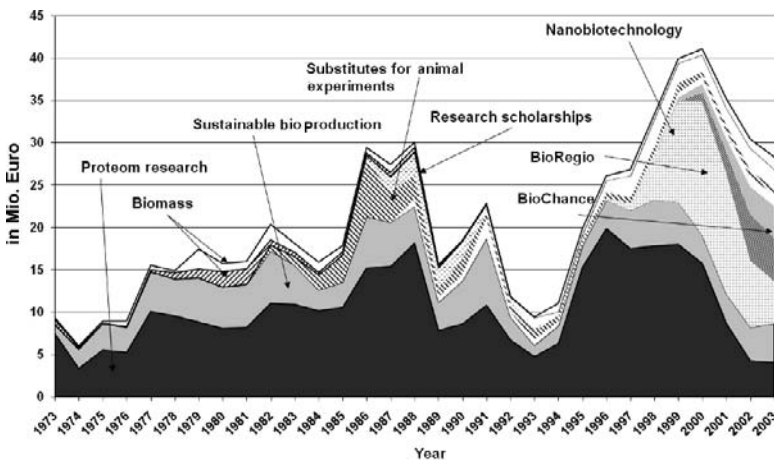
Fig. 10.1 Federal funding by biotechnology programmes in the business enterprise sector (Germany 1973–2003) (source BMBF/ZEW)

that the high international standard of performance in the life sciences will be maintained. BioRegio was initiated to push the commercialization of biotechnology in Germany and thus create internationally outstanding centres of excellence. At the same time, the BioRegio contest changed the general Federal governments' philosophy in public R&D funding, programmes were restructured to increase more transparency and linked with other funding programmes, e.g. for health research and production engineering. Moreover the corporate design of funding programmes was changed for biotechnology in Bio'X', such as BioRegio, BioChance, BioFutur, BioProfile.

10.4 The Principles of R&D Policy and its Dramatic Changes

In the biotech-boom of 1994–2001, the public R&D funding was basically justified by improving human health, making careful use of the environment, as well as safeguarding and creating jobs. A comparison of key technologies and public budgets show significant changes. In the particularly funding area of biotechnology, funding stepped up in 1997 with 137% and again doubled until 2000 (BMBF, 1998). While the number and projects of German biotech firms was small and manageable until the unification, the situation of R&D policy changed dramatically since the 1990s for four reasons:

1. Policy makers did believe in a technology driving a "catching-up" process and a further economic takeoff in the new Länder (former German Democratic Republic). For this reason and in the context of the demand of (new) firms and research facilities, the direct R&D project schemes were not just opened to East Germany but improved in terms of easy funding application conditions.
2. Germany takes part in the world-wide race to decode human genotype. In 1996 the German Human Genome Project (DHGP) was launched by politics, science and industry in which funds increased by 70%. Moreover, Germany has pushed and agreed to the Fourth EU Framework Programme for Research which appropriates three times as many funds for biotechnology as the previous programmes.
3. Biotechnology patents—one of the most important aspect for industry, start-up firms and R&D policy—were recognized as crucial and a contemporary issue. In this respect, the DHGP was aimed at the systematic and comprehensive patenting of research results thus ensuring the efficient translation of these results into innovative products and services.
4. National and foreign investors were searching for new fast growing technologies, firms and markets. European governments recognize venture capital as a perfect completion to typical bank loans and public subsidies in the field of high innovative new technology firms. A new culture of financing close to the NASDAQ in the US and similar activities in the UK was asked for and implemented as an own segment at most stock markets (e.g. 'New Market' at the German Stock Exchange).

While the number of German biotech companies was pretty small and all companies well known to R&D policy makers, the "takeoff" in biotech exceeded all expectations. After the kick off period of the biotechnology industry in the 1990s, more than 300 companies were established at the beginning of the century. The slow down of the economic growth of the last three years affected the expected number of biotechnology companies but still results in 350 companies in 2003 (Ernst and Young, 2004). This boom of biotech firms was accompanied—and maybe initiated—by the Federal Governments R&D policy. The BMBF pushed its project management agencies. Each project proposal is embedded in research programme announcements which clarify the funding objectives for each company to receive a potential financial support. The majority of the programmes straighten out in their byelaws that a fundamental precondition is a substantial research as well as a market risk which represents a clear disadvantage for the company.

In addition, the risk must take a shape of preventing access to different resources e.g. financial resources. The funding objectives of the other programmes underline the fact that the research content should meet a potential market, should have a great innovation potential and should foster joint ventures with already established companies in the particular market. While in 1993 about 40 biotech firms have already achieved a public R&D project grant this number increased up to 130 firms in 1997. In this period, the traditional public funding procedures split up in several new approaches such as contests, competitions and lead-projects. In 1999, the Federal government counts for 280 biotech firms in Germany and publicly funded at least 180 firms (64%) by direct project grants.

The total number of publicly funded R&D projects was increasing from 52 projects in 1993 to 266 projects in 2001. If we take into account that firms carry out several R&D activities and apply for different biotech policy schemes the mean number of publicly funded R&D projects per firm is about 1.5 projects. In the year 2003 we do observe a total number of 350 Biotech companies in Germany. About 170 firms (49%) have been publicly funded in 219 R&D projects. The total amount of public R&D project funding in the German biotech industry is almost Ǎ 28.8 million on average (see Figure 10.2: graph total subsidies corresponds to the right side vertical axis) and because of the matching grants requirements (cost-sharing) almost Ǎ 57.8 million have been invested by industry and government each year. The forthcoming empirical study focuses on this commitment.

The hypothesis we will inspect is whether R&D policy in the field of biotechnology was carried away by the enthusiastic mood concerning this technology and if R&D policy tends to ignore its own principles. Do we observe a private business R&D funding which did not discriminate biotech firms in different 'risks'? Do we observe a "watering-can R&D funding policy"? In this case, public R&D project grants might damage a suspected economic uplift because firms are forced to concentrate on (basic) R&D activities while they become totally engrossed of the needs of the market.
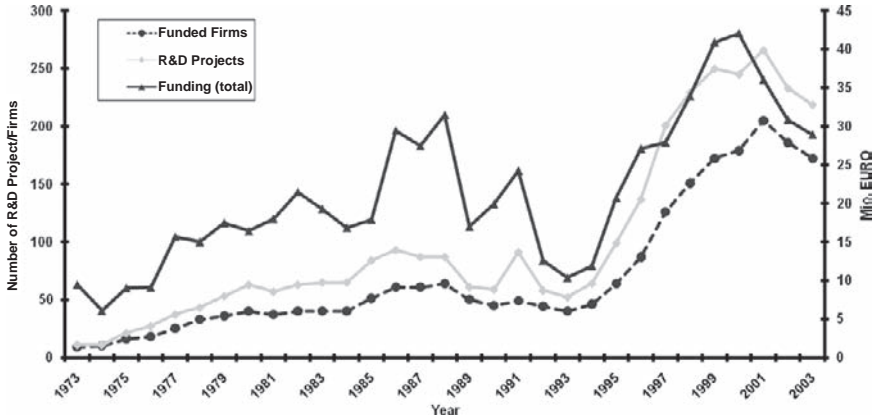
Fig. 10.2 Number of funded firms, R&D projects and total amounts of public R&D biotech funding in the business enterprise sector (BMBF 1993–2003)

10.5 Empirical Approaches Towards Public Funding

10.5.1 Financial, Technical and Market Risk in the Field of Biotechnology

New technologies and their relationship towards uncertainty and risk is subject of some of the classic works in economics (Knight, 1921; Schumpeter, 1911, 1943; Kirzner, 1973). Besides notable studies which focus on science and public basic research, economists in particular analyse the commercialisation of new discoveries and in this context different risks. Risk and uncertainty are inherent in the nature of high-tech innovation. In general three major kinds of risk occur: financial risk, technical risk and market risk. The embodiment of a the specific risk structure of the biotechnology industry can be characterised as follows:

Financial risk: Recently, but more apparent in the high-tech boom years of the 1990s, technology entrepreneurs complain about a shortage of R&D funding capital while large sums still remain in venture capital funds or banks. Because of this observation economists and governments diagnose that established markets do not internalize risk capital to early-stage technologies. With respect to Spence's (1984) theoretical reflection such inefficiency concerns limits of the ability of investors in early stage technologies to fully appropriate returns from the investment. Moreover even worse serious inadequacies in information to both entrepreneurs and investors arise because of technical uncertainties. Given these uncertainties investors prefer to hold back rather than to make speculative investments (Carpenter and Petersen, 2002). Considering the credit market model by Diamond (1989), a long credit history does have a positive impact on the interest charges. In the contrary, a bad credit history occurs by young companies facing risky projects which lead into a moral hazard problem. The credit history is displaying the reputation in a market.[7]

The crucial point is that past performance of a company meets a reputation effect. Newly created high-tech biotechnology firms carrying out research and development projects require considerable financial resources up to one billion US dollars depending on the business model and business field. Especially the red biotechnology sector which is comparable with the pharmaceutical industry faces high R&D costs. The product companies of this sector are confronted with the uncertainty of a regular drug development process. This argumentation is underlined by using business field and business model variables to measure risk. Therefore, central concerns are the existing financial constraints which hamper the possibility of growth and future development, especially at a start up stage.

Technical risk: A second group of risk centres on the technical risk of innovation. After substantial investments in R&D, a new product may not be feasible or may have only limited market appeal (Chesbrough, 1999). This sort of risk refers to the probability that a development project eventually turns into a marketable product. Nelson (1959) emphasized the importance of uncertainty in distinguishing the research process from development process. He argues that the uncertainty of research is much greater than for the development part. Brealy and Myers (2000) classify technical risk into three groups: availability of competencies and complementary technologies required to deliver the technology, specification achievability and probability of success. All of them merge in upcoming young biotechnology companies. In particular, the technological risk is portrayed again by the business model and the business field. The high uncertainty of the R&D process which is preferably undertaken by product companies is especially subject to the red biotechnology. The drug development process could spend over twelve years without realizing any returns (Di Masi et al., 2003). The combination of the long term development process and the high risk of product failure characterize the biotechnology industry (Müller and Herstatt, 2004).

Market risk: Market risk or systematic risk has often been described in the literature as the degree of uncertainty associated with gaining a competitive advantage due to environmental factors (Barney, 1991; Fiet, 1991, 1995; Porter, 1980). The notion of "risk" and "uncertainty" in economics and the distinction between these concepts was recognized by Knight (1921). In his view risk and uncertainty are associated with imperfect knowledge. Therefore risk in a biotechnological project is a measure of the inability to achieve the objectives within cost and time schedule and the surrounding financial constraints. Fiet (1995) focused his study of market risk on start-ups and identified the following indicators as a proxy for market risk: technical obsolesce, many competitors, many potential, new competitors, many substitute products, weak customer demand and market attractiveness. A major task of innovation policy is to overcome such economic burdens and different measures like low-interest loans, grants, tax incentives are in place aiming to stimulate R&D activities. The most important German measure is the so called 'direct R&D project funding' of the Federal Government, because of a lack of tax incentives. Its general purpose is the "support of particular risky, extensive and long-term projects" (BMBF, 2003). More detailed and in the case of biotechnology, the application requirements explicitly mention R&D projects with a "high risk in research" related

to financial gaps in this concern. Innovative firms involved in the biotech sector are technological pioneers and do have a larger probability to fail compared to traditional businesses. These firms have to be characterized as being more risky with regard to their technologies and prospects.

In line with our thesis, we argue that receiving public funding does not happen accidentally but rather being subject to a selection processes and public funding principles. Therefore, a possible strategy of the decision maker could be the selection of very promising applicants to pursue a "picking a winner" strategy. Several information asymmetries could occur as well in case of very small companies which do not have the information of the public funding programmes or the resources to apply for. All together have a great impact on these selection processes which could distort the analysis by not taking them into account. The probability of public funding measures the effect of not being funded by chance. The estimation of this probability is a crucial part of the analysis to consider the selectivity of being just applicant to a funding programme or being funded. The following analysis focuses on the risk issue. We test if public R&D funding processes take any risk related to biotech companies into account. If public R&D policy works, we would expect a higher probability of public funding for companies which have to fight specific risks.

We will measure 'financial risks' by the credit rating of a biotech firm. Biotech companies, which do not have a long track record suffer from financial constraints which is observed in low credit ratings. If public funding take into account such risk, we would expect a higher probability for applying and getting funds if firms do have low credit ratings. We will measure 'technical and market risks' by indicating the business field and the business model a biotech firm is involved. The business field (red, green, grey biotech)[8] indicates technical risk, because the red biotech is much more demanding in legal requirements, development cycles and extensive tests compared to the green or grey biotechnology. In this context the red biotechnology has higher risks of failure and should get a higher probability of being publicly funded. In the current case of biotechnology, the classical differentiation of 'market risk' is especially portrayed in the business model services i.e. a lot of companies could provide the same service of e.g. DNA-sequencing which leads to many competitors in one special domain. The greatest market attractiveness is of course shown by the red biotechnology sector which have the possibility in case of success to develop a blockbuster drug which provides high benefits. In our research setting we first identify variables which represent firm's risk concerning R&D, investments and markets. Using a probit model we estimate the probability of getting public R&D project grants simultaneous controlling for different measures of 'risk'.

10.5.2 Data

The analyses are based on data from the ZEW Foundation Panel, which was started in early 1990. The firm-specific data are provided by the largest German credit rating agency CREDITREFORM. This agency systematically records all firms which have a commercial registration ('Handelsregistereintrag'). In addition, inquiries about the

financial situation of the respective firm by customers or suppliers play a major role regarding the recording of new, incorporated firms (Stahl, 1991; Harhoff and Stahl, 1995). Almost every six months, information on newly recorded start-ups and updated information on existing firms are delivered and integrated into the panel, though updated information is not available for each firm at each delivery (Harhoff and Steil, 1997). Information collection from public registers, newspapers, company reports and in firm interviews is an ongoing process such that the frequency of information updating varies among firms. A typical firm record in the panels provides a lot of information about firm formation, insolvency fillings and liquidation. Moreover, it indicates the firm's location, industry classification, number of employees, legal status, ownership and management details (Prantl, 2003).

The CREDITREFORM data set covers more than eight million firms. For this reason it is now possible to identify all German biotechnology companies in this data set. Besides the above-named available information, CREDITREFORM provides a so called "free float text" with additional information about the firm, among other things a detailed description of the firm's business activities. The information about the business activities specifies the biotechnology company. Being interested in the subset of all biotechnology companies, a special search algorithm is used to identify them. In a second step, a list with biotechnology related words e.g. genetic, biotechnology, DNA etc. is created to describe the business activities of a biotechnology company. The search is now an iterative process i.e. it takes different runs until the subset is ready. During the different search processes, the "biotech-word list" must be adjusted different times to specify the search process. Before declaring the final data set as a final one, the subset has to be checked with the BIOCOM database, one of the biggest commercial databases in Germany. After this process the final data set contain 1,529 biotechnology companies in Germany. In order to perform an empirical analysis, we link the CREDITREFORM data with the PROFI database. The PROFI database covers the civilian R&D funding of the German federal government. The PROFI database includes reliable information on all projects and recipients funded by the BMBF and BMWA since 1980, i.e. almost all subsidized civilian R&D projects are covered. The database permits an analysis of expenditure in terms of research themes, projects, recipients, funding procedure etc. (Czarnitzki and Fier, 2003). The match of these two datasets has resulted in a new subset of 158 biotechnology companies which have been subsidized by the German government.

10.5.3 Empirical Consideration and Descriptive Statistics

We use the complete survey of German biotech firm characteristics from 1994–2004. Within this eleven year period, we count for 1,529 different biotech companies in Germany. For about 41% of these firms we have eleven year panel observations, where we notice the number of employees, the credit rating, the number of patent applications and further firm characteristics in every year. For about 56% of the firms we do observe at least three or more observations. With regard to public funding we

know the exact year of being funded for the first time in a biotech scheme and the size/amount of the award in euros. Cross-section we do have 12,433 observations (see Table 10.1 for descriptive statistics).

The dependent variable in the empirical analysis is the firm's status concerning public project funding. This status depends on a firm's decision to apply for public R&D funding as much as it depends on the federal government's decision to award a R&D project proposal. In this context we estimate the probability for applying and awarding a public grant at the same time. In the probit analysis, we use a dummy variable (FUND$_{it}$) indicating whether the particular firm i has received public funding in time t. With regard to the tobit estimation we use FUNDSUM$_{it}$ which shows the total amount of the grant. For both models we control for firm characteristics using variables which are important with regard to the funding application and awarding process (financial risk, technical risk, market risk).

Our exogenous firm's indicator for 'financial risk' is the credit rating index (CREDIT). This measure indicates whether a firm has financial constraints and might apply for public R&D funding as an alternative to the capital market to finance its R&D activities. In the total sample the credit rating index is about 262 in the mean, while 100 is the best and 600 the worst index. Moreover, a VC dummy shows if venture capital company holds shares and is involved in the biotech's business. Venture capital seems to be very important in this field of technology because about 19% of all German biotech companies are backed by VC. 'Technical and market risk' is measured by the business field and in the business model, a biotech firm is involved; the dummy variables RED and GREEN indicate whether the company's main field of biotechnology belongs to the red or green biotech activities (gray biotech is the basis). The business model is characterized by suppliers (SUPP), producers (PROD) and service providers (SERV) to differentiate between market orientation and kind of R&D activities. Of course, we include firm size measured as the log of number of employees LNEMPLO. Since Schumpeter's seminal thoughts about innovation (Schumpeter, 1934, 1943), it is indisputable that firm size has an impact on innovative activities, e.g. such as patenting. We also include LNEMPLO^2 to allow for non-(log)linearity. Additionally to firm size, we also include firms' age defined by age as explanatory variable AGE as well as AGE^2.

Because biotechnology started to become famous in the 1990s in Germany, it is assumed that very young firms may be more likely to get a public R&D project grant. All regressions include a dummy which denotes Eastern German firms as those may behave different due to the still ongoing transformation process of the Eastern German economy (EAST). The variable COMP indicates if a company of any industry holds shares of a particular biotechnology company. The variable PATENT represents the patent stock which is computed from the time-series of patent applications at the European Patent Office. The patent stock controls for the variation of the propensity to patent among firms. Moreover, seven sector dummies on basis of the NACE classification should capture different technological opportunities among business sectors. In principle, these dummies are created according to the NACE two-digit sectoral classification. However, some sectors are merged due to a low number of observations.

Table 10.1 Descriptive statistics of the German biotech survey (1,529 firms)

Variables		Mean	Std. Dev.	Min.	Max.
Endogenous					
FUND	Public funding dummy [0/1]	*0.187*	*0.135*	*0*	*1*
FUNDSUM	Total public funding amount [€]	*13,272.40*	*141,689*	*0*	*4,669,610*
Exogenous					
Age	Age [years]	9.352	18.728	0	145
Employ	Employees [number]	64.742	462.952	0	9700
Credit	Credit rating [index]	255.05	78.783	101	600
Patent	Patent applications [number]	1.794	2.91	0	6.596
Green	Business field: green biotech [0/1]	0.133	0.34	0	1
Red	Business field: red biotech [0/1]	0.677	0.467	0	1
Grey	Business field: grey biotech [0/1]	0.097	0.296	0	1
Prod	Business model: producer [0/1]	0.55	0.497	0	1
Supp	Business model: supplier [0/1]	0.218	0.413	0	1
Serv	Business model: service provider [0/1]	0.26	0.439	0	1
East	Location East Germany [0/1]	0.169	0.375	0	1
VC	Venture capitalist involved [0/1]	0.19	0.392	0	1
Comp	Further company's shares [0/1]	0.311	0.463	0	1

Note: The variables in the analysis also include seven industry dummies (IND1-IND7) and eleven time dummies (TIME1-TIME11) and not reported here.

Source: Creditreform/ZEW
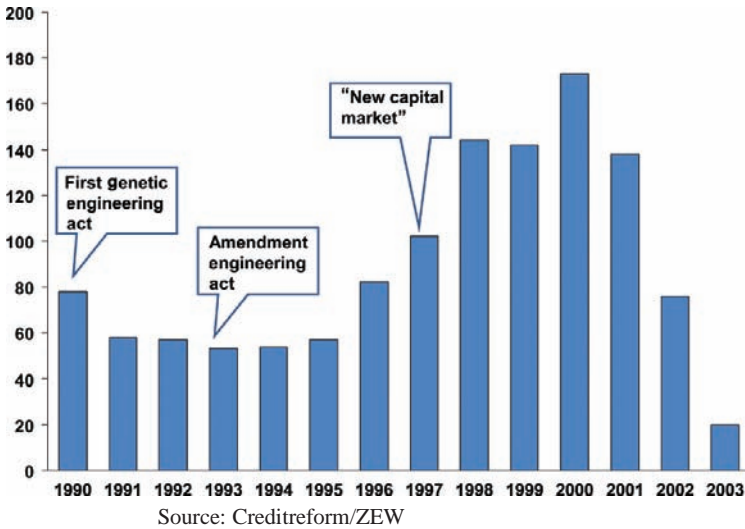
Fig. 10.3 New formation of biotechnology companies 1990–2003

10.5.4 Entrepreneurial Activity of the Biotechnology Sector

As we mentioned earlier, biotechnology firms differ in the level of future outcomes and the level of uncertainty to realize the outcomes. In the past, the formation of new high-tech biotech firms in the last 15 years is characterized by ups and downs. Several influencing factors got a great impact of the entrepreneurial activity of the German biotechnology sector. Figure 10.3 points out that the regulation did influence the sector and led into a restrictive entrepreneurial behavior marked by taking no operational risks in the beginning of the 90s. The time period 1990–1994 is clearly labeled by the effect of the first Genetic Engineering Law. For example, in 1993 less than 50 new companies started a new venture compared to 2000 with more 170 new companies. Subsequently, the after-effect of a positive cyclical trend, the reform of the Genetic Law and the possibility of getting access to the capital market (Neuer Markt) for young companies is reflected in the rising numbers of start-ups in this sector.

Furthermore, the entrepreneurs of the biotechnology companies of this sample could also be differentiated. Biotech entrepreneur is a person who is involved with own assets in a newly founded biotech firm and who plays a key role in the firm's business activities. Such a key role will be assumed if the person works in the senior management team of the new firm. In the result, our dataset contains 1,886 entrepreneurs. Data on the home region of entrepreneurs before they engaged in start-up activity is from ZEW-Foundation Panel. Table 10.2 shows the four groups of entrepreneurs according the local embeddedness and affinity to research of the entrepreneur. All local entrepreneurs with a doctoral degree (= local scientists) form the group of embedded entrepreneurs. Local non-scientists and non-local founders

Table 10.2 Number of Biotech entrepreneurs from 1995 till 2003 according the local embeddedness of founders and their affinity to research

Entrepreneur's siting before he or she becomes an entrepreneur	Entrepreneur's highest educational level	
	Doctoral degree	Lower than doctoral degree
Inside the region of firm location	Local scientist (N = 1,154)	Local non-scientist (N = 243)
Outside the region of firm location	Non-local scientist (N = 390)	Non-local non-scientist (N = 101)

Notes: Bold letters marks the group of embedded-entrepreneurs.

(non-local scientists and non-local non-scientist) count to the group of the non-embedded ones. The differentiation shows that 61% of entrepreneurs are highly embedded. Scientists moving in from other regions are the second important group of biotech entrepreneurs. One fifth of all entrepreneurs are non-local scientists. As expected, non-scientists are less important and provide about one fifth of entrepreneurs.

10.6 Empirical Study

We apply different models to analyze firm characteristics and their impact of being funded. Most of the OECD governments such as Germany commit themselves to stimulate basic research and high risky R&D to reduce the private cost of innovation. Therefore firms' incentives for carrying out R&D could be fully re-established through appropriated public funding (Spence 1984). Subsequent to our hypothesis we estimate probit and tobit models on the likelihood of public funding first and consider a homoscedastic and a heteroscedastic model, too. We also performed LM tests and LR tests (Greene, 2000). In our robust probit, a dummy variable is indicating whether the firm received public R&D funding or not. In a tobit model we take into account the amount of public grants. Considering the amount is important because firms might only apply for a R&D funding or will be funded if the total project amount is considerable and cover the expenses of funding application process. The following multivariate analysis enables to control for effects of other variables simultaneously. Accordingly, we estimate separately the likelihood of the funding status (FUND) and serving as dependent variables with the following estimation equation:

$$P(FUND_i = 1|x_i) = F(x_i'\beta), \qquad (10.1)$$

where x_i contains the explanatory variables and F is the cumulative standard normal distribution. The equations for the other co-operation dummies are analogous (Greene, 2003). On the basis of the estimation results we check if the variables of

Table 10.3 Probit estimations on public R&D funding

	PROBIT-Estimation		TOBIT-Estimation	
Endogenous	FUND Dummy variable [0/1]		FUNDSUM Public funding amount [€]	
Exogenous Var.	Coefficient	t-value	Coefficient	t-value
Log(Employ)	0.285	4.25***	450690.7	4.05***
Log(Employ^2)	−0.042	−3.82***	−65790.7	−3.53***
CREDIT	−0.001	−2.23**	−1855.5	−1.67*
AGE	−0.045	−7.42***	−76782.2	−6.07***
AGE^2	0.000	7.70***	715.5	6.77***
PATENT	0.070	5.97***	118719.7	6.30***
RED	0.344	3.44***	475132.5	3.12***
GREY	0.251	2.07**	313954.8	1.62
PROD	0.131	1.67*	242012.4	1.93*
SERV	−0.149	−1.92*	−221296.5	−1.75*
VC	0.097	1.26	134660.4	1.10
COMP	0.114	1.57	229258.6	2.02*
EAST	−0.077	−0.85	−123277.6	−0.84
const.	−3.747	−8.26***	−6075651.0	−7.31***
Observations	N = 8.213		N = 8.213	
Pseudo R^2	0.20		0.18	

Notes: Significant at the 1%-level (***), 5%-level (**), 10%-level (*). The variables in the analysis also include seven industry dummies (IND1-IND7) and eleven time dummies (TIME1-TIME11) and not reported here.

the hypotheses still have a significant impact. In the aforementioned context we control for firm-specific characteristics as well as for project-specific issues (public funding/amount). The results of the models are presented in Table 10.3.

With respect to the probability of participating in the federal government's public R&D funding schemes and the particular 'risk' status of biotech companies, we do observe similar results in the probit estimations: Concerning financial risk we do observe a negative relationship on the credit rating index, means if the credit rating index (CREDIT) is going worse the chance of getting public funds is also poor. Moreover we did not find influences on public R&D funding if a venture capital company (VC) is involved. With regard to technical risk and market risk, there is a good chance for biotech companies which are producers (PROD) and belong to the business field of red biotechnology (RED). These companies do have a have significant higher probabilities to get public R&D grants compared to their counterparts. Especially service providers (SERV) just have poor chances of being publicly funded if they compete with supplying or producing applicants. Moreover we do find an inverse U-shaped relationship of getting R&D grants if we consider the size of biotech firms (EMLOY) and a U-shaped relationship concerning age (AGE). In general, the probability of being publicly funded is higher the more employees are registered and if a biotech firm is pretty young. The patent dummy indicates if a biotech company does have a knowledge stock and hence the potential to innovate.

These firms also have higher probability of getting R&D project funds. However, we do not realize any significant influences on the probability of being funded if other companies are involved in a biotech firm or if the biotech company is based in Eastern Germany.

10.7 Conclusions

This study focused on the emerging biotechnology industry in Germany in the last couple of years. Investors and business leaders still have considerable expectations concerning its growth rates in employment, new products, patents and profits. The technology is most relevant for society to foster the national competitiveness, employment and social wealth. Especially, policy makers do attach importance to the biotechnology industry in the last decade. Therefore we report empirical results on the German R&D policy regarding biotechnology companies. We first explain the low numbers of companies involved in this technology until the 1990s and give reasons for the pleasant catching-up process we do observe in the following years. However, our main thesis is that public R&D policy did not discriminate in funding new technologies such as biotechnology any more. We maintain that public R&D funding neglects its own principles if we focus on different characteristics of 'risk'. In general we would expect that biotech firms which have high financial, technical or market risks belong to the recipients of public R&D grants. For this reason, we carry out probit estimations to determine public funded R&D.

In the estimated model we control e.g. for different industries, age, credit history, number of employees, venture capital investments, company investments, patent stock, East Germany as well as for particular business fields and business models which might have an influence on the probability of receiving public R&D subsidies. According to financial constraints we find that firms with a poor credit history i.e. with a lower credit rating do have poor chances of being publicly funded. Having a closer look on the particular activities of the biotechnology companies, the results give us significance concerning other risk issues. Technical and market risk is measured by different business models and we found that high risk producing biotech firm are in favor of being publicly funded. This is in line with the business fields (RED) which have a higher probability of receiving funding than firms engaged primarily in the green biotech (GREEN) sector. The red biotechnology is characterized by uncertainty which is tied with the duration and the costs of the R&D process. This could take more than a decade including costs up to 600 million US dollars.

Another interesting fact is that a venture capital investment does not yield in a higher probability of getting R&D subsidies which seems to be a signal of having a financial resource to undertake R&D projects. It is important to mention that the results described above do indicate the present picture of the biotechnology scene in Germany. In fact, there is no biotechnology company which is producing products in the red sector and at the same time having an outstanding credit history. The governments' strategy of public funding is not focused on companies which have

to fight financial risks. Companies which have a poor credit history (CREDIT) and for this reason even slight chances to get loans at the capital markets do also have a smaller chance of being publicly funded. In this respect public funding authorities prefer to 'pick potential winners' but hold away to foster firms and technologies which have poor credit ratings. On the other hand, we do observe a higher probability of being funded if a firm is involved in the high risky red biotechnology. We assume that these firms do have a higher probability because governments tend to fund human life sciences first. Moreover, public funding agencies do not prefer East German firms. Our results represent that our dummy EAST is not significant which indicates that R&D funding seems to be independent from a regional emphasize of East Germany. However, we just controlled for East Germany without going closer to a regional level but according to earlier studies, East Germany did benefit from different funding tools. We find no evidence for a stronger consideration of biotechnology companies located in East Germany.

In case of size and age of companies, larger and younger biotechnology firms do have a higher probability of receiving public funding. We do assume that such large and young biotech companies are large company spin-offs instead of university spin-offs or start-ups. This is in line with the significance of the PATENT variable. The accumulation of knowledge i.e. having patents, gives a clear signal for every investor that the company have the ability to formulate new scientific findings. Companies which have been founded out of large pharmaceutical or chemical firms do count for more patents compared to original start-ups. For this reason, we control for further company shares (COMP), but just can not find a small hint in the tobit model. On the basis of these empirical results, we see that the German R&D policy is not strictly focused on biotech companies which have to fight a bundle of risks (financial, technical, market risk). However, the governments do not misapply their funding e.g., by fostering companies which are already playing in a non-risk business field with a non-risk business model. But it is important to mention that these results do not give any implication of the efficiency and the excellence of these selected companies of this emerging industry.

Notes

[1] Although governments are the major players in stimulating private business R&D, private foundations too offer R&D grants. However, non-profit foundations fostering R&D—especially technology driven scientific foundations—are in particular more established in the USA rather than in Europe.

[2] Hoechst (1950) and Bayer (1952) used these licences to use these new technologies.

[3] DNA = deoxyribonucleic acid and proteins are the biological molecules most often used in biotechnology. DNA provides instructions for making cells and performing cellular tasks, while proteins provide the building materials for producing new cells and are responsible for carrying out the DNA's instructions.

[4] After the second World War the allies decide to break up the major war machinery industries into single and civilian companies. The Uhde Ltd. was decentralised as a former part of the IG Farben Inc. In the 1950, it becomes a subsidiary of the Hoechst Inc. The know-how of Hoechst, which

use licensed US technologies, was passed to Uhde Ltd. in the fields of organic chemicals, plastics and synthetic fibres. Uhde's 'Hoechst Branch' is a company of ThyssenKrupp Technologies Coop., today. The Gelsenberg Fuel Inc. was Germany's most important fuel and gas provider during the war and was destroyed in 1944. After 1950 the company was build up and becomes in 1955 an important fuel company, again. Gelsenberg Inc. was integrated into the Vereinigte Elektrizitäts- und Bergwerks-AG (VEBA). VEBA and Gelsenberg AG, like all shareholders of Ruhrkohle AG, were formerly mining companies and transferred their mining holdings to Ruhrkohle AG in 1969.

[5]In 1989, Hoechst Inc. was forced to close a production facility of genetic products by law and relocated it outside of Germany.

[6]This contest was initiated in 1995 by the federal ministry of education and research (BMBF) and encouraged regions to apply for subsidies to be used in establishing a biotech industry in the region. The BMBF's main goal was to stimulate the transfer of new knowledge into new products and thereby lessen the distance between Germany and those countries leading in the application of biotechnological knowledge, i.e. the US and Great Britain. Regions were invited to submit a development concept meant to help establish the biotech industry in their region for appraisal (see Dohse, 2000, for details).

[7]There is a growing literature on the effect of reputation in markets—noteworthy of the papers by Klein and Leffler (1981), Shapiro (1983), Rogerson (1983) and Allen (1984).

[8]As opposed to the situation in the health care ("red") biotechnology sector, the agricultural and food market ("green" biotech) offers much less growth perspectives in Europe, due to a low level of acceptance from users (farmers, consumers) as well as difficulties experienced in the technology development and regulatory approval. The market for environmental applications ("gray" biotech) is viewed as being economically insignificant compared to the two previous ones.

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Chapter 11
Technological Strategies and Firm Characteristics: A Study of Indian Basic Chemical Industry

Savita Bhat and K. Narayanan

11.1 Introduction

Globalization, a term describing the phenomenon of business units originating in one country but becoming an essential participant in markets worldwide, has become an intrinsic characteristic of most of the contemporary economies. These global businesses or multinational companies (MNCs) have successfully entered into many sectors including agriculture, industry and service. Frequently their presence in the sector has lead to transformation in the behavior of the passive indigenous units compelling them to adopt different, generally more efficient and productive technological and managerial practices, thus ultimately leading to the growth of the sector. With the advent of globalization, the firms all over the world operating in industries that are sensitive to business cycles of other industries to which they are suppliers, like the Basic Chemicals segment, have been able to successfully hedge the impact of country specific business cycles. In other words, globalization has led to higher amount of financial collaborations, joint ventures, and technical collaborations to take place all over the world, including India.

It is now well established that by using an appropriate competitive technological strategy a firm may be able to survive effectively in any environment (see Basant, 1997; Siddharthan and Safarian, 1997; Lall, 2001; Narayanan, 1998, 2004; Siddharthan and Rajan, 2002, for studies in Indian context). The technological strategy itself is determined by the technological regime in which the firm operates where technological regime consists of various factors, some internal and some external

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to the firm, that together determine the diverse conditions faced by the firms while operating in the industry.

Ever since independence, the Indian government has tried to introduce various policy instruments that can influence Indian business units' environment and thus their active behavior. Initially, when India was having an inward-looking regime where licensing and import tariffs ensured that the firms did not face much competition from within as well outside, there were companies that imported capital goods and technology (Bell and Scott-Kemmis, 1985) with the aim of either reverse-engineering and learning or directly using the newly imported technologies for improving their position in the domestic markets. After the economic liberalization of 1991, the environmental conditions in the Indian sectors changed substantially, with the restrictions of controls and regulations being dispensed off and the central role being given to the market forces. This changed scenario became conducive for globalization to spread in India and now MNCs are competing with indigenous Indian business units in almost all the sectors. In order to be at par with the competitive MNCs, the indigenous business units are more rigorously following one or more of different active behaviors like advertising, doing research and development, upgrading their units by importing embodied or disembodied technology, carrying out product diversification, colluding, merging with or acquiring other firms and so on.

In the light of above developments, the present study uses a panel data sample consisting of 91 firms belonging to Basic Chemical industry for a period of seven years (from 1997 to 2003). The aim of the study is to analyze the pattern that emerges with respect to the different technological strategies adopted by firms having different entrepreneurial qualities. Here, technological strategies are defined in terms of the choices available to the entrepreneur as regards to the combination of four major modes of innovative efforts that it can adopt in the year. The four major modes of innovative efforts are: in-house R&D, import of embodied technology (in the form of import of capital goods), import of disembodied technology (from the market through lump sum payments, royalties, and technical fees) and foreign equity participation. The study considers that the entrepreneur decides on an appropriate technological strategy based on its quality. The quality of the entrepreneur is affected directly by the kind of ownership and indirectly by the scale of the operation (market share of firm), the knowledge earned over time (age of firm), internal financial resources (profit margins of the firm) and the degree of internalization (vertical integration of the firm) of the firm. The study also tries to highlight the patterns that emerge with regards to the kind of R&D (incremental or rigorous) used by an entrepreneur in this industry.

Section 11.2 will deal with the review of literature. Section 11.3 will discuss the data and methodology used in the study. Section 11.4 will explore the patterns that emerge when the firm characteristics are tabulated against the degree of technological combination strategy. The final section would summarize the findings.

11.2 Review of Literature

This section deals with literature survey on innovation and firm characteristics. The focus is mainly on studies dealing with Indian industries, though studies on other countries have also been mentioned.

Innovation as defined by Kamien and Schwartz (1982) includes 'all those activities, from basic research to invention to development and commercialization, that give rise to a new product or means of production.' Thus innovation can be considered to include all those activities that lead to process and/or product related improvements in a firm. Cohen and Levin (1989) too observe that one of the fundamental problem in the study of innovation and technical change in industry is the absence of proper measure of new knowledge and its contribution to technological progress. Therefore they note that studies have frequently employed innovative measures based on either innovative inputs (sources) or outputs.

In the Indian context Desai (1985) observed six sources of technology being utilized by the manufacturing firms. These included technology imports and corporate R&D. Recent studies in the Indian context (Basant, 1997; Siddharthan and Safarian, 1997; Narayanan, 1998, 2004; Siddharthan and Rajan, 2002) have considered innovative sources in mainly four forms: in-house R&D, import of capital goods, import of designs, drawings and formulae through royalties, technical fees and lump sum payments, and foreign direct investments.

In-house R&D is the source of building knowledge through internal means. Generally, it takes the form of incremental improvements in the given process or product through minimal investment. However, a firm may invest substantial amount on in-house R&D in order to bring about revolutionary technique of production or a novel product in the market. Import of capital goods, that is, machinery and equipment brings with it the latest technology though it is embedded in the capital good itself. The firm may be able to introduce a better product in the market by merely using the newly acquired machinery. However, over time the actual technology embodied in the capital good may get diffused in the industry through means of reverse engineering. Some firms may try to acquire technology in disembodied form through import of designs, drawings and formulae against royalties, technical fees and lump sum payments. The products or processes introduced by the firm using these designs and drawings may again be new to the local market until the technology gets diffused.

A strategic behavior commonly seen in firms belonging to developing countries is the import and adapt (IAT) strategy (Katrak, 1989). Frequently firms that import technology also use in-house R&D for adapting the technology to suit local conditions. This is especially seen during the initial stages of technological development. In case of India, empirical studies such as Siddharthan (1992) and Sujit (2004) have found technology imports and in-house R&D to be complementary. Siddharthan and Rajan (2002) too on the basis of their survey of literature and various case studies conclude that in India's context technology transfer and in-house R&D efforts are by and large complementary and so the successful strategy for firms would be to have an in-house R&D base along with import of technology.

Foreign equity participation can also be a mode for acquiring new technological and managerial practices through intra-firm knowledge transfer. These are mainly tacit knowledge transfers that help the firm in improving its overall capabilities and thus achieving a better position in the market (Siddharthan, 1992; Siddharthan and Safarian, 1997). Frequently, in developing countries such as India, foreign firms are willing to part with this knowledge only when they have a stake in the local firm's equity. Apart from the tacit knowledge transfer the foreign (equity) collaborators may also induce increased in-house R&D and technology imports in the local firms suggesting a package deal for technology transfer. With an aim of improving its position in the market, an entrepreneur would have to decide on the combination of the various sources of technology to invest on. This decision, however, would be influenced by the entrepreneurial quality of the firm. In the present study the authors look at five firm characteristics, which indirectly capture the quality of the entrepreneur. The five firm characteristics considered are ownership, market share, age, profit margin and degree of vertical integration of the firm. An entrepreneur can both directly or indirectly choose to adopt a specific level of these characteristics, and thus determine its own quality.

Romijn (1996) has observed that the extent to which a firm engages in technological efforts is influenced by ownership category as well. Whenever required a firm belonging to a business house can easily get resources for investing in innovative activities from other firms under the same business family. Again, the innovation strategy of a firm associated to an MNC would generally be influenced by the policies and practices of its parent firm. Thus the affiliation of the firm would directly reflect the quality of the entrepreneur and can therefore influence the technological strategy adopted by the entrepreneur.

Market share of the firm captures the scale of operation of the firm. It also represents the relative position or size of the firm with respect to other firms in the market. Given its technological abilities, an entrepreneur can decide as to what proportion of its resources it would like to devote for production and what proportion for other investment activities such as innovative efforts. Thus, the scale at which an entrepreneur decides to operate on can influence the technological strategy that it adopts.

Many studies have asserted that innovative efforts are highest in larger and/or leading firms (Schumpeter, 1943; Brozen, 1951; Mansfield, 1963, 1964; Braga and Willmore, 1991; Kumar and Saqib, 1996; Basant, 1997; Sujit, 2004). Some of the reasons sited (Brozen, 1951; Mansfield, 1963; Symeonidis, 1996) in favor of the view are involvement of large fixed costs which can only be covered when sales are sufficiently large; scale and scope economies in the production of innovations; exploitation of unforeseen innovations by large diversified firms; spreading the risks of R&D by large firms through undertaking of many projects at a given time; and better access to external finance for the large and/or leading firms. However, there are also counter arguments (Symeonidis, 1996) such as existence of decreasing returns to scale in the production of innovations due to loss of managerial control and bureaucratization of innovative activity and sluggishness due to market power in the absence of strong competitive pressures. Still others (Scherer, 1965; Kamien

and Schwartz, 1975; Kamien, 1989) believe that both large and small firms have a role in the innovation process since each can concentrate on the tasks it does relatively better. For example, a large firm can focus on innovation in capital-intensive technologies and small firm can focus on innovation in labor-intensive technology.

The evolutionary framework (Nelson and Winter, 1977) and the capability literature (Lall, 2001) recognize the importance of time (experience) or learning by doing in influencing the technological strategy chosen by an entrepreneur. According to studies dealing with evolutionary framework (Nelson and Winter, 1977; Basant, 1997; Narayanan, 1998) technological regime or technological paradigm can be considered as design configuration including policy environment that acts as a framework for production or operation of a firm in an industry and the trajectories as the paths of advancement within the given technological regime/paradigm. The firms, over time, try to achieve different technological sophistication by either shifting to a different trajectory of operation through innovation in existing processes and products or shifting to a totally new technological paradigm through inventions. The capability literature recognizes that with age, firms can accumulate technological capabilities, which in turn can influence the strategy of the firm for shifting to a different technological trajectory and/or paradigm. Though shifting to what trajectory or paradigm may be determined by the prevailing capabilities of the firm, however, firms often put in extra efforts in the form of technological investments to acquire further capabilities that would make the trajectory and/or paradigm shift a success. Thus, the level of capabilities that the firm chooses to acquire over time also reflects the quality of the entrepreneur which in turn influences the kind of technological strategy that the firm is willing to invest on for further enhancement of its capabilities.

Another quality that surfaces as an important factor in deciding the technological strategy adopted by an entrepreneur is based on the ability of the entrepreneur to raise finance for investment. A firm may either get finance as a loan from financial institutions like banks or may reinvest its own profits. As the theory of internal financing suggests, taking a loan may involve commitment and high risk and so firms may prefer internal financing to taking loans. A similar viewpoint emerges when Kamien and Schwartz (1975) assert that only firms generating a substantial cash flow would be able to support a sizable R&D effort since they may be unwilling or unable to borrow large funds to finance development of a new product or process. This means that high current profits, as a source of liquidity, are necessary for in-house R&D. Thus, profit margins of the firm would reflect the quality of the entrepreneur in terms of its ability to generate internal finance for investing in different innovative sources.

According to the theory of firm, ease of entry to and exit from any industry also determines the behavior of the firms in that industry. Frequently high vertical integration in the firms has been considered as a form of entry barrier for other new firms trying to enter an industry (Hay and Morris, 1991; Brocas, 2003; Narayanan and Banerjee, 2004).

Vertical integration captures the extent to which the firm carries out the various functions like purchasing, employment, design, production, and sales within the

firm. In other words, it captures the extent to which the firm has internalized various stages of production. The downstream producer, that is, the firm that is buyer of a technology or component may find it profitable to integrate with upstream innovator, that is, the seller of the component or technology, especially if the underlying efficient technology is costly. Once the supplier and buyer of the technology are integrated, any rival firm cannot easily compete using the same technology. Since all aspects of production would be internalized, therefore higher vertical integration in the firm may lead to reduction in technology purchase from the market against licenses and royalties and have moderate effect on R&D intensity. Cohen and Levin (1989) assert that a firm's degree of vertical integration may actually increase the amount of R&D undertaken because of the possibility of economies of scope (producing more than one product in the same plant) and diversification. Thus, depending on the threat that it is facing, an entrepreneur may decide on what proportion of operations to internalize and what proportion to subcontract. In the process the entrepreneur would also decide as to the mode of innovative efforts that it would like to adopt.

11.3 The Data and Methodology

This section will discuss the data and methodology used in the study. The definition of the various firm characteristics considered in the study would also be highlighted.

The Indian Chemical industry can be thought to be consisting of three segments, namely, Basic, Specialty and Knowledge chemicals (KPMG India-CHEMTECH Foundation, 2003). Basic chemicals segment can be considered to constitute of firms producing intermediate chemicals that are used as inputs in other firms belonging to various other industries such as Pharmaceutical, Rubber, Leather, Plastics and so on.

As indicated in Section 11.1, this study uses a balanced panel data consisting of 91 firms from the Indian Basic Chemical industry for the period from 1997 to 2003. The source of the data is the Capitaline-2000 database. Pooling of data has been done since it ensures that any abnormalities specific to certain year do not affect the results. Firm-wise data on affiliation, sales turnover, gross profits, year of incorporation, expenditure on R&D, expenditure on imports of capital goods, expenditure on lump sum, royalty, and technical fees, value-addition by the firm, and foreign collaborator/promoter share have been collected for the analysis.

The technological strategies considered are in terms of various combinations of four major sources of innovations, namely, research and development intensity (RDI), capital goods import intensity as a proxy for embodied technology imports intensity (MKI), disembodied technology (in the form of lump sum, royalty, and technical fee payments) imports intensity (LRI), and foreign equity participation. The methodology consists of empirically analyzing the differences in the technological strategies adopted by the firm that emerges as per the differences in the firm characteristics such as affiliation, firm size (MS), age of the firm (AGE), profit

margin (PROFIT) and vertical integration (VI) of the firms. Four types of affiliations of the firms have been considered in the study, that is, affiliation to business houses, affiliation to government, MNC associates, and unaffiliated (for firms that do not belong to other three affiliation category). Table 11.1 describes the other firm characteristics and their definitions used in the study.

Table 11.2 shows the mean, variance, minimum and maximum values of the variables for the sample of 637 observations. As can be observed from Table 11.2, the sample has average market share at around 0.9% with the largest firm having a market share of only around 8%. The mean value of intensity for R&D, import of embodied technology and import of disembodied technology is less than 0.5% and the highest level of intensity for all the three sources of technology is below 7%. Further, the firms operating in the industry seem to be quite experienced as the mean age of the firms in the industry is around 26 years with the oldest observation being 82 years old. The variance in vertical integration is the highest, closely followed by the variance in profit margin. This implies that the sample consists of observations where the firms are highly integrated as well as observations where there is hardly any integration in the firm. Similarly there are highly loss-making firms along side firms that are high profit makers.

11.4 Empirical Analysis

This section will define the combinational forms of the four sources of innovation. Then an empirical analysis using cross-tabulations would be carried out. Finally the correlation matrix of the firm characteristics would be discussed.

Depending on which of the four basic strategies, namely, in-house R&D (RD), capital goods import (MK), and technology imports (LR), and foreign equity participation (FE) a firm is using simultaneously in the given year, sixteen mutually exclusive and exhaustive technological behaviors can be formed (Table 11.3). The number of observations, (percentages in parenthesis) of the 637 total observations, that are using the particular sub-strategy has also been indicated in the last but one column of Table 11.3. It can be clearly seen that around 2/3rd of the total observations did use technological strategies during the time period of analysis. The strategy of using only R&D was most popular (10.52%) among the technologically active firms. However the strategy of using only foreign equity participation was also not far behind with around 7.53% of the observations opting for the same. Overall it seems that among the different modes of technology acquisition, import of technology through arm's length purchases was the least preferred strategy except when it was accompanied with import of capital goods. After liberalization, the relaxations in the import restrictions must have led to investment in technical knowledge through payments in the form of technical fees, royalties, and lump sums complemented with importing of capital goods such as containers, boilers, and other apparatus for high scale production.

Table 11.1 Variables, symbols, and definitions used in the study

Variable name	Symbol used	Definition used in the study
1. Research and development intensity	RDI	$\dfrac{\text{Expenditure on R\&D}}{\text{Sales turnover of the firm}} * 100$
2. Embodied technology (capital goods) import intensity	MKI	$\dfrac{\text{Expenditure on import of capital goods}}{\text{Sales turnover of the firm}} * 100$
3. Disembodied technology import intensity	LRI	$\dfrac{\text{Lump sum, royalty, and technical fees payments in foreign currency}}{\text{Sales turnover of the firm}} * 100$
4. Firm size or market share	MS	$\dfrac{\text{Sales turnover of the firm}}{\text{Sum of the sales turnover of all the firms}} * 100$
5. Age	AGE	One + (the year of incorporation - the year in the study)
6. Profit-margin	PROFIT	$\dfrac{\text{Gross profit earned by the firm in the year}}{\text{Sales turnover of the firm}} * 100$
7. Vertical integration	VI	$\dfrac{\text{Value addition by the firm}}{\text{Sales turnover of the firm}} * 100$
8. Foreign presence	DFOR	Dummy variable with DFOR = 1 when foreign collaborator/promoter shares exist in the equity DFOR = 0 otherwise

Table 11.2 Mean and variance of variables used in the analysis

Variables	Symbol	Mean	Variance	Min. Value	Max. Value
1. R&D intensity	RDI	0.386	0.941	0	6.71
2. Import of embodied technology (capital goods) intensity	MKI	0.005	0.0006	0	0.397
3. Import of disembodied technology intensity	LRI	0.114	0.217	0	4.61
4. Age of firm	AGE	25.74	204.713	1	82
5. Profit-margin	PROFIT	4.375	534.326	−211.111	66.437
6. Vertical integration	VI	35.178	557.829	2.992	433.333
7. Firm size (market share)	MS	0.892	1.225	0.00095	7.963

Number of Observations (N) = 637.

In Table 11.3, column four shows the degree of technological strategy. A degree of zero is assigned for those observations that are not using any of the four innovative sources in the particular year. Degree of one is assigned for the cases where the firm is using only one of the four modes in the year. Similarly a degree of two and three respectively stands for the observations where either two or three of the four major strategies are being used simultaneously. Finally a degree of four is assigned to the observations that are making use of all the four modes of technology acquisition.

As can be clearly observed from Table 11.3, for degree one the popular strategies are in-house R&D, foreign equity participation, closely followed by import of capital goods. Among degree two, import of capital goods with in-house R&D stands out in comparison to the rest of the strategies. All the degree three strategies seem to be popular to more or less similar extent. But one can clearly observe that a combination of all four together is more popular than each of the sub-strategies of degree two or three. Tables 11.4 and 11.5 investigate the pattern that emerges when the technological strategies are tabulated against affiliation of the firm in the observation. As can be observed from Table 11.4, more than half of the unaffiliated observations are not investing in any of the four technological strategies. In contrast most of the MNC associates in the sample are actively investing in technological strategies of degree three and four, thereby supporting the idea of package deal of technology transfer in foreign affiliates. The technologically active firms who are unaffiliated and who are affiliated to business houses have favored a strategy of degree one as compared to other degrees during the study period. A look at Table 11.5 however reveals that among the strategies of degree one, the unaffiliated firms have mainly preferred in-house R&D and foreign participation in equity, whereas the firms affiliated to business house do not have such clear preference. Technological strategies of degree two and three are also popular in affiliates of business houses.

Tables 11.6–11.13 try to see how the entrepreneurial quality of the firm in terms of its scale of operation, age and experience, degree of vertical integration, and profit margins influence the technological strategy chosen by the firm during the study period. Tables 11.6, 11.8, 11.10, and 11.12 are based on degree of technological

Table 11.3 The technological strategies

Sl.	Sub-strategy	Symbol	Degree	Does the firm use?				NOB (Out of 637)	NOB (for each degree)
				FE	LR	MK	RD		
1	Not using any	NONE	0	No	No	No	No	203 (31.87%)	203
2	Only R&D	RD	1	No	No	No	Yes	67 (10.52%)	171
3	Only import of embodied tech.	MK	1	No	No	Yes	No	38 (5.96%)	
4	Only import of disembodied tech.	LR	1	No	Yes	No	No	18 (2.83%)	
5	Only foreign equity	FE	1	Yes	No	No	No	48 (7.53%)	
6	Only import of embodied tech. with R&D	MK_RD	2	No	No	Yes	Yes	32 (5.02%)	111
7	Only import of disembodied tech. with R&D	LR_RD	2	No	Yes	No	Yes	14 (2.20%)	
8	Only imports of disembodied tech. with import of embodied tech.	LR_MK	2	No	Yes	Yes	No	20 (3.14%)	
9	Only foreign equity with R&D	FE_RD	2	Yes	No	No	Yes	16 (2.51%)	
10	Only foreign equity with import of embodied tech.	FE_MK	2	Yes	No	Yes	No	20 (3.14%)	
11	Only foreign equity with import of disembodied tech.	FE_LR	2	Yes	Yes	No	No	9 (1.41%)	
12	Only import of disembodied & embodied tech. with R&D	LR_MK_RD	3	No	Yes	Yes	Yes	26 (4.08%)	108
13	Only foreign equity with import of embodied tech. and R&D	FE_MK_RD	3	Yes	No	Yes	Yes	28 (4.40%)	
14	Only foreign equity with import of disembodied tech. and R&D	FE_LR_RD	3	Yes	Yes	No	Yes	21 (3.30%)	
15	Only foreign equity with import of disembodied and embodied tech.	FE_LR_MK	3	Yes	Yes	Yes	No	33 (5.18%)	
16	All together	FE_LR_MK_RD	4	Yes	Yes	Yes	Yes	44 (6.91%)	44

Table 11.4 Distribution with respect to affiliation (degree-wise)

Sl.	Technological strategy	Un-affiliated	Kind of affiliation		MNC	Total
			Business house	Government		
1	Zero	131 (50.58)	66 (24.81)	6 (21.43)	–	203 (31.87)
2	One	62 (23.94)	100 (37.59)	5 (17.86)	4 (4.76)	171 (26.84)
3	Two	38 (14.67)	53 (19.92)	9 (32.14)	11 (13.09)	111 (17.42)
4	Three	19 (7.34)	42 (15.79)	6 (21.43)	41 (48.81)	108 (16.95)
5	Four	9 (3.47)	5 (1.88)	2 (7.14)	28 (33.33)	44 (6.91)
6	All	259 (100)	266 (100)	28 (100)	84 (100)	637 (100)

Notes: Each cell of the table gives the number of observations with column-wise percentages in parenthesis.

Table 11.5 Distribution with respect to affiliations (specific technological-strategy-wise)

Sl.	Technological strategy	Un-affiliated	Kind of affiliation		MNC	Total
			Business house	Government		
1	None	131 (50.58)	66 (24.81)	6 (21.43)	–	203 (31.87)
2	RD	27 (10.43)	39 (14.66)	1 (3.57)	–	67 (10.52)
3	MK	7 (2.70)	28 (10.53)	3 (10.71)	–	38 (5.96)
4	LR	5 (1.93)	12 (4.51)	1 (3.57)	–	18 (2.83)
5	FE	23 (8.88)	21 (7.89)	–	4 (4.76)	48 (7.53)
6	RD_MK	10 (3.86)	21 (7.89)	1 (3.57)	–	32 (5.02)
7	RD_LR	–	7 (2.63)	7 (25.00)	–	14 (2.20)
8	RD_FE	5 (1.93)	8 (3.01)	–	3 (3.57)	16 (2.51)
9	RD_MK_LR	1 (0.39)	23 (8.65)	2 (7.14)	–	26 (4.08)
10	RD_MK_FE	2 (0.77)	8 (3.01)	1 (3.57)	17 (20.24)	28 (4.40)
11	RD_LR_FE	9 (3.47)	7 (2.63)	–	5 (5.95)	21 (3.30)
9	RD_MK_LR_FE	9 (3.47)	5 (1.88)	2 (7.14)	28 (33.33)	44 (6.91)
10	Others	30 (11.58)	21 (7.89)	4 (14.29)	27 (32.14)	82 (12.87)
11	All	259 (100)	266 (100)	28 (100)	84 (100)	637 (100)

Notes: Each cell of the table gives the number of observations with column-wise percentages in parenthesis.

strategies. Tables 11.7, 11.9, 11.11, and 11.13 try to further enquire the type of technological strategy (especially the R&D based ones) that have been popular during the period under study.

Tables 11.6 and 11.7 depict the distribution of technological strategies with respect to market share of the firms. As can be clearly seen during the period most of the small scale observations have not been technologically as active as the large scale ones. For the smaller firms R&D has been quite popular as a technological strategy of degree one, but for the relatively larger firms capital goods import was also equally desirable. Firms with only foreign equity participation are also clearly visible in the smallest and the largest categories. Table 11.8 and 11.9 represent the distribution of the technological strategies based on the experience of the entrepreneur. As can be seen in Table 11.8, older firms are technologically more active than their younger counterparts. During the study period investing on individual modes of technological strategies has been quite popular with the middle-aged

Table 11.6 Distribution with respect to market share of the firm (degree-wise)

Sl.	Degree of technological strategy	Market share (in percentage) ranges				Total
		<0.236	0.236−0.473	0.473−0.710	≥0.710	
1	Zero	113 (61.75)	53 (38.97)	12 (12.90)	25 (11.11)	203 (31.87)
2	One	36 (19.67)	47 (34.56)	33 (35.48)	55 (24.44)	171 (26.84)
3	Two	19 (10.38)	19 (13.97)	14 (15.05)	59 (26.22)	111 (17.42)
4	Three	11 (6.01)	12 (8.82)	19 (20.43)	66 (29.33)	108 (16.95)
5	Four	4 (2.18)	5 (3.68)	15 (16.13)	20 (8.89)	44 (6.91)
6	All	183 (100)	136 (100)	93 (100)	225 (100)	637 (100)

Notes: Each cell of the table gives the number of observations with column-wise percentages in parenthesis. Market Share of 0.473% is the median value for 637 observations.

Table 11.7 Distribution with respect to market share of the firm (specific technological-strategy-wise)

Sl.	Technological strategy	Market share (in percentage) ranges				Total
		<0.236	0.236−0.473	0.473−0.710	≥0.710	
1	None	113 (61.75)	53 (38.97)	12 (12.90)	25 (11.11)	203 (31.87)
2	RD	13 (7.10)	26 (19.12)	13 (13.98)	15 (6.67)	67 (10.52)
3	MK	5 (2.73)	8 (5.88)	10 (10.75)	15 (6.67)	38 (5.96)
4	LR	1 (0.55)	5 (3.68)	4 (4.30)	8 (3.56)	18 (2.83)
5	FE	17 (9.29)	8 (5.88)	6 (6.45)	17 (7.56)	48 (7.53)
6	RD_MK	–	8 (5.88)	4 (4.30)	20 (8.89)	32 (5.02)
7	RD_LR	–	3 (2.21)	–	11 (4.89)	14 (2.20)
8	RD_FE	4 (2.19)	1 (0.73)	4 (4.30)	7 (3.11)	16 (2.51)
9	RD_MK_LR_FE	4 (2.18)	5 (3.68)	15 (16.13)	20 (8.89)	44 (6.91)
10	Others	26 (14.21)	19 (13.97)	25 (26.88)	87 (38.67)	157 (24.65)
11	All	183 (100)	136 (100)	93 (100)	225 (100)	637 (100)

Notes: Each cell of the table gives the number of observations with column-wise percentages in parenthesis. Market Share of 0.473% is the median value for 637 observations.

firms. The firms in age group from 22 to 33 years have favored R&D investment as compared to other strategies of degree one. It is interesting to note that nearly 16% of the oldest firms have invested on the technological strategy of degree four during the period though doing only in-house R&D has also been a popular strategy.

Tables 11.10 and 11.11 give the distribution of the technological strategies with respect to the degree of vertical integration of the firms. As can be seen in Table 11.10, higher percentages of technologically active firms are in the moderately vertically integrated firms' category of between 16 and 48%. The firms in the sample that have invested in a technological strategy of degree four also belong to the same category of vertical integration. Nearly 17% of the observations that are highly vertically integrated have chosen only foreign equity participation as a strategy of degree one.

Tables 11.12 and 11.13 give the distribution of technological strategies with respect to the entrepreneur's quality of raising internal finances that is reflected in the profit margins of the firms. Nearly half of the loss making observations is not technologically

Table 11.8 Distribution with respect to age of the firm (degree-wise)

Sl.	Degree of technological strategy	Firm age (in years) ranges				Total
		<11	11−22	22−33	≥33	
1	Zero	36 (52.17)	107 (44.96)	40 (30.53)	20 (10.05)	203 (31.87)
2	One	12 (17.39)	64 (27.31)	51 (38.93)	44 (22.11)	171 (26.84)
3	Two	7 (10.14)	33 (13.87)	20 (15.27)	51 (25.63)	111 (17.42)
4	Three	13 (18.84)	24 (10.08)	18 (13.74)	53 (26.63)	108 (16.95)
5	Four	1 (1.45)	10 (4.20)	2 (1.53)	31 (15.58)	44 (6.91)
6	All	69 (100)	238 (100)	131 (100)	199 (100)	637 (100)

Notes: Each cell of the table gives the number of observations with column-wise percentages in parenthesis. Age of 22 years is the median value for 637 observations.

Table 11.9 Distribution with respect to age of the firm (specific technological strategy-wise)

Sl.	Technological strategy	Firm age (in years) ranges				Total
		<11	11−22	22−33	≥33	
1	None	36 (52.17)	107 (44.96)	40 (30.53)	20 (10.05)	203 (31.87)
2	RD	5 (7.25)	17 (7.14)	28 (21.37)	17 (8.54)	67 (10.52)
3	MK	2 (2.90)	19 (7.98)	6 (4.58)	11 (5.53)	38 (5.96)
4	LR	3 (4.35)	8 (3.36)	4 (3.05)	3 (1.51)	18 (2.83)
5	FE	2 (2.90)	20 (8.40)	13 (9.92)	13 (6.53)	48 (7.53)
6	RD_MK	–	13 (5.46)	7 (5.34)	12 (6.03)	32 (5.02)
7	RD_LR	–	1 (0.42)	5 (3.82)	8 (4.02)	14 (2.20)
8	RD_FE	–	4 (1.68)	–	12 (6.03)	16 (2.51)
9	RD_MK_LR_FE	1 (1.45)	10 (4.20)	2 (1.53)	31 (15.58)	44 (6.91)
10	Others	20 (28.98)	39 (16.39)	26 (19.85)	72 (36.18)	157 (24.65)
11	All	69 (100)	238 (100)	131 (100)	199 (100)	637 (100)

Notes: Each cell of the table gives the number of observations with column-wise percentages in parenthesis. Age of 22 years is the median value for 637 observations.

Table 11.10 Distribution with respect to vertical integration of the firm (degree-wise)

Sl.	Technological strategy	Vertical integration (in percentage) ranges				Total
		<15.994	15.994−31.988	31.988−47.982	≥47.982	
1	Zero	32 (60.38)	84 (31.58)	46 (20.09)	41 (46.07)	203 (31.87)
2	One	10 (18.87)	74 (27.82)	63 (27.51)	24 (26.97)	171 (26.84)
3	Two	7 (13.21)	32 (12.03)	55 (24.02)	17 (19.10)	111 (17.42)
4	Three	4 (7.55)	52 (19.55)	45 (19.65)	7 (7.86)	108 (16.95)
5	Four	–	24 (9.02)	20 (8.73)	–	44 (6.91)
6	All	53 (100)	266 (100)	229 (100)	89 (100)	637 (100)

Notes: Each cell of the table gives the number of observations with column-wise percentages in parenthesis. Vertical integration of 31.988% is the median value for 637 observations.

active. Of the other half, most are investing on degree one technological strategy of which R&D and foreign equity participation are the popular ones. For the marginal profit making firms R&D based strategy seems to be quite popular. However other technological strategies also gain importance with increase in profit margins.

Table 11.11 Distribution with respect to vertical integration of the firm (specific technological strategy-wise)

Sl.	Technological strategy	Vertical integration (in percentage) ranges				Total
		<15.994	15.994−31.988	31.988−47.982	≥47.982	
1	None	32 (60.38)	84 (31.58)	46 (20.09)	41 (46.07)	203 (31.87)
2	RD	4 (7.56)	27 (10.15)	33 (14.41)	3 (3.37)	67 (10.52)
3	MK	2 (3.77)	11 (4.13)	20 (8.73)	5 (5.62)	38 (5.96)
4	LR	2 (3.77)	11 (4.13)	4 (1.75)	1 (1.12)	18 (2.83)
5	FE	2 (3.77)	25 (9.40)	6 (2.62)	15 (16.85)	48 (7.53)
6	RD_MK	−	8 (3.01)	22 (9.61)	2 (2.25)	32 (5.02)

Notes: Each cell of the table gives the number of observations with column-wise percentages in parenthesis. Vertical integration of 31.988% is the median value for 637 observations.

Table 11.12 Distribution with respect to profit margins of the firm (degree-wise)

Degree of technological strategy	Profit margin (in percentage) ranges					Total
	<0	0−4.604	4.604−9.208	9.208−13.812	≥13.812	
Zero	63 (50.81)	46 (40.71)	38 (26.57)	21 (19.27)	35 (23.65)	203 (31.87)
One	40 (32.26)	30 (26.55)	36 (25.17)	26 (23.85)	39 (26.35)	171 (26.84)
Two	14 (11.29)	21 (18.58)	24 (16.78)	22 (20.18)	30 (20.27)	111 (17.42)
Three	6 (4.84)	10 (8.85)	33 (23.08)	27 (24.77)	32 (21.62)	108 (16.95)
Four	1 (0.81)	6 (5.31)	12 (8.39)	13 (11.92)	12 (8.11)	44 (6.91)
All	124 (100)	113 (100)	143 (100)	109 (100)	148 (100)	637 (100)

Notes: Each cell of the table gives the number of observations with column-wise percentages in parenthesis. Profit Margin of 9.208% is the median value for profit making (513) observations.

In order to have a better idea of the distribution of R&D (incremental or rigorous) undertaken by the firms in the Indian Basic Chemical industry and to have a better idea as to what is the quality of the entrepreneur undertaking the type of R&D two more tables, that is, Table 11.14 and 11.15 have been constructed. Based on the median value of R&D intensity for the R&D doing firms two types of R&D have been defined. First is incremental R&D where the firm is generally believed to be doing minimal R&D for improving on the existing product or process and second is rigorous R&D where the firm is investing substantial amount on R&D generally with the hope of introducing a new product in the market. As can be observed from Table 11.14 most of the observations that are doing incremental R&D are not investing on other technology modes. However, the observations that are doing rigorous R&D are also using other technological sources. It seems that the entrepreneurs in the Indian Basic Chemical industry do not have the capabilities of doing breakthrough research on their own. Rather, they seem to be simply introducing new products in the Indian market by suitably adapting the technology originated in foreign country.

Again, from Table 11.15 it is clear that most of the unaffiliated firms are doing incremental R&D. In contrast most of the foreign affiliates are doing rigorous

Table 11.13 Distribution with respect to profit margin of the firm (specific technological strategy-wise)

Sl.	Technological strategy	Profit margin (in percentage) ranges					Total
		<0	0−4.604	4.604−9.208	9.208−13.812	≥13.812	
1	None	63 (50.81)	46 (40.71)	38 (26.57)	21 (19.27)	35 (23.65)	203 (31.87)
2	RD	17 (13.71)	21 (18.58)	14 (9.79)	6 (5.50)	9 (6.08)	67 (10.52)
3	MK	3 (2.42)	2 (1.77)	9 (6.29)	5 (4.59)	19 (12.84)	38 (5.96)
4	LR	1 (0.81)	3 (2.65)	5 (3.49)	5 (4.59)	4 (2.70)	18 (2.83)
5	FE	19 (15.32)	4 (3.54)	8 (5.59)	10 (9.17)	7 (4.73)	48 (7.53)
6	RD_MK	4 (3.22)	10 (8.85)	4 (2.80)	6 (5.50)	8 (5.40)	32 (5.02)
7	RD_LR	1 (0.81)	5 (4.42)	5 (3.49)	2 (1.83)	1 (0.68)	14 (2.20)
8	RD_FE	5 (4.03)	2 (1.77)	6 (4.20)	1 (0.91)	2 (1.35)	16 (2.51)
9	RD_MK_LR_FE	1 (0.81)	6 (5.31)	12 (8.39)	13 (11.92)	12 (8.11)	44 (6.91)
10	Others	10 (8.06)	14 (12.39)	42 (29.37)	40 (36.70)	51 (34.46)	157 (24.65)
11	All	124 (100)	113 (100)	143 (100)	109 (100)	148 (100)	637 (100)

Notes: Each cell of the table gives the number of observations with column-wise percentages in parenthesis. Profit Margin of 9.208% is the median value for profit making (513) observations.

Table 11.14 Distribution based on R&D

Sl.	Technological strategy (Based on R&D)	Type of R&D incremental	Rigorous	Total
1	RD	55 (44.71)	12 (9.60)	67 (27.02)
2	RD_MK	10 (8.13)	22 (17.60)	32 (12.90)
3	RD_LR	9 (7.32)	5 (4.00)	14 (5.64)
4	RD_FE	12 (9.76)	4 (3.20)	16 (6.45)
5	RD_MK_LR	5 (4.06)	21 (16.80)	26 (10.48)
6	RD_MK_FE	5 (4.06)	23 (18.40)	28 (11.29)
7	RD_LR_FE	15 (12.19)	6 (4.80)	21 (8.47)
8	RD_MK_LR_FE	14 (11.38)	30 (24.00)	44 (17.74)

Notes: Each cell of the table gives the number of observations with column-wise percentages in parenthesis. The median R&D intensity during the study period for R&D doing firms is 0.52%. In the present study, an R&D doing firm that has R&D intensity of less than 0.52% is defined to be doing incremental R&D and the R&D doing firm having R&D intensity of greater than or equal to 0.52% is defined to be doing intensive R&D.

R&D. The firms affiliated to business houses are investing on both incremental and rigorous R&D. Further, Table 11.15 reveals that the relatively larger, older, and better profit margin firms are investing on rigorous R&D. Table 11.9 shows the correlation matrix for three of the technology source variables, namely, R&D intensity (RDI), import of capital goods (MKI), and import of disembodied technology (LRI), and the firm characteristics, that is, market share (MS), age of the firm (AGE), profit-margin (PROFIT) and vertical integration (VI). As can be seen profit margin is positively correlated to intensities of the three basic technological strategies. This complements the result obtained from Tables 11.12 and 11.13 that increasing profit margin is not just associated with an increase in degree of technological strategy but also with an increase in the intensities of the individual strategies.

Table 11.15 Distribution of type of R&D with respect to firm characteristics

Sl.	Type of R&D	No. Obs.	None	Affiliation type business house	Govt.	MNC	Mean firm characteristics			
							MS%	AGE	PROFIT%	VI%
1	Incremental	123	49	54	9	13	0.6	28.87	5.69	33.12
2	Rigorous	125	14	64	5	40	2.19	34.23	9.38	33.44
Mean values of firm characteristics for all 637 observations							0.89	25.74	4.37	35.18

Table 11.16 Correlation matrix between the variables

Variables	RDI	LRI	MKI	AGE	PROFIT	VI	MS
RDI	1						
LRI	−0.042	1					
MKI	−0.018	0.043	1				
AGE	0.266**	0.187**	−0.027	1			
PROFIT	0.093*	0.098*	0.092*	0.005	1		
VI	−0.025	−0.055	0.004	0.022	−0.405**	1	
MS	0.523**	0.155**	0.017	0.293**	0.092**	−0.109**	1

Notes: ** and * represent 1 and 5% significance level respectively.

Age is positively correlated to R&D and disembodied technology import intensities implying that older and more experienced firms are the ones investing in higher proportions on these two technological strategies. Market share is also positively correlated to R&D and import of technology intensities, indicating that Schumpeter's (1943) theory (larger firms are more technologically active) might hold for the Indian Basic Chemical industry. Again market share is positively correlated to age; which means that older firms are also the ones that are large. Degree of vertical integration is negatively correlated to both profit-margin and market share, at the same time profit-margin is positively correlated to market share suggesting that highly vertically integrated firms are the loss making small firms. Finally, it should be noted that there is no statistically significant positive correlation between the intensities of investments on the three basic technological strategies suggesting that though package deal of the technological strategies seem to be a popular technological strategy among Indian Basic Chemical firms, the relationship between the sources of technology on the whole may not be complementary.

11.5 Summary and Conclusions

The study tried to understand the patterns seen in the adoption of technological strategies based on four major sources of innovation when tabulated against some of the entrepreneurial qualities in the Indian Basic Chemical industry sample. Efforts were also made to understand the nature of R&D investments in this industry. Further, a correlation matrix between the firm characteristics was computed to

investigate the existence of a possible complimentary relationship between the individual technological strategies. The important insights gained from the study that are especially relevant for Indian Basic Chemical industry are:

1. The firms in this industry are investing on various sources of innovation. During the study period, nearly 2/3rd of the observations in the sample were technologically active with many investing in technological strategies of degree two and higher.
2. The firms that are unaffiliated and those affiliated to business houses are preferring investments in individual sources of technology. In contrast the MNC affiliates are investing on technological strategies of order three and four. This implies the foreign firms are using a package deal of technology transfer. Further, as compared to domestic unaffiliated firms more numbers of foreign affiliates and nearly half of the R&D doing business house firms are investing on rigorous R&D. It is likely that foreign affiliates are trying to introduce new products in the market through adaptation of imported technology. Some of the business house affiliates may also be trying a similar strategy. However, the domestic unaffiliated firms seem to be merely trying to improve upon the existing technologies, most probably due to lack of sufficient resources.
3. As compared to smaller firms the larger firms are technologically more active. Moreover, larger firms are also the ones that are doing more rigorous R&D. The correlation matrix too shows statistically positive coefficients for market share with R&D as well as import of disembodied technology imports. This means that the larger firms with their vast resources are in a better position to invest on technological activities in Indian Basic Chemical industry.
4. Higher percentages of older and experienced firms are technologically active. Again, positive correlation coefficients between age of the firm and, R&D intensity and import of disembodied technology intensity suggest that the framework provided by the evolutionary and capability economists holds for the Indian Basic Chemical industry. In other words the quality of the entrepreneur becomes better over time due to capability acquisition and thereby positively influencing the innovative efforts of the firm.
5. Moderately vertically integrated firms are technologically more active than either the highly sub-contracting or the highly integrated types. Again, the moderately vertically integrated firms are also the ones that are investing on technological strategy of degree four. This implies that some amount of internalization of production which would determine the production capability of the firm might be necessary before the firm can explore other technological sources.
6. Some of the loss-making firms are also investing on technological strategies with only R&D and foreign equity being popular among the technologically active loss-making firms. The firms with relatively better profit margins are investing on rigorous R&D. The correlation coefficient between profit and technological investments is also positive. This justifies the idea that the entrepreneur's ability to generate internal resources is also quite important for deciding the amount and type of technological strategy to invest on.

7. While profit margin is positively correlated to firm size, vertical integration is negatively correlated to both firm size and profit margin. Thus one can say that high vertical integration results in high cost of management in the small organizations leading to losses in those firms. In other words smaller firms may benefit from being sub-contracting types in the Indian Basic Chemical industry.

8. Although, by and large, the active firms in the Indian Basic Chemical industry prefer a combination strategy, suggesting a package deal of the technological strategies, the complementary relationship between the four major technological strategies may not hold since there is no statistically significant correlation between the intensities of R&D, import of capital goods and import of disembodied technology. However, a thorough analysis of the causal relationship needs to be carried out to draw firmer conclusions.

Thus, the present study highlights how the differences in the quality of the entrepreneur due to ownership, scale of operation, experience, degree of vertical integration and ability to raise internal finances can affect the type of technological strategy that the entrepreneur chooses to invest on. It seems that the firms in this industry are mainly adopting the technologies bought from abroad. Though the industry is quite a matured one, still, being the backbone for many other industries, it is an important one. Therefore there is a need to encourage the unaffiliated firms in this industry to do pioneering research.

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Chapter 12
Diversity and the Geography of Technology Entrepreneurship: Evidence from the Indian IT Industry

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12.1 Introduction

This chapter combines two striking features of recent global economic development. Firstly, entrepreneurship is a rising phenomenon in India with a second place in Total Entrepreneurial Activity (TEA) index among 37 countries in the world according to the Global Entrepreneurship Monitor (GEM, 2002). Secondly, Indian IT in itself attracts increasing scholarly interest. Most of the research (Arora et al., 2004) is centered on presumably generic factors of the Indian economy in the context of offshoring and outsourcing, i.e. a well-educated and English-speaking workforce that is cheaply available. This chapter focuses on the analysis of geographical concentrations of IT industry and the co-evolution of supportive institutions. The chapter employs a mixed methodology consisting of qualitative and quantitative methods. The former is based on primary interview data, in order to generate hypotheses, and the latter uses various sources of secondary data to corroborate these empirically. The main hypotheses are that education, venture capital and socio cultural factors such as ethnic and gender diversity influence the pattern of knowledge-intensive industries like software.

The chapter is structured as follows. Section 12.2 reviews the literature on technology entrepreneurship and geographical clustering. Section 12.3 adds to this literature hypotheses based on my own fieldwork. Section 12.4 presents empirical evidence and section 12.5 concludes.

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12.2 Theory and Hypotheses: Entrepreneurship and Clusters

Since most of the literature is mainly concerned with advanced economies, this review will be mainly confined to these countries as well; differences from emerging markets will be added in the next section focusing on the Indian context. The aim is not to give an exhaustive overview of the literature but rather to bring together insights from the related literatures of the economics of location and entrepreneurship.

There is no consensus in the literature about what entrepreneurship actually is. Theoretical positions range from risk taking to merely founding a new venture; whereas some agreement has been established over the individual micro-level nature of the entrepreneurial process (Carroll and Khessina, 2005). In this chapter, I do not wish to delve into this theoretical discussion but rather employ the narrowly defined notion of firm founding. There is considerable evidence in extant literature suggesting that such firm founding is regionally concentrated in clusters (Audretsch and Keilbach, 2004, 2005). This concentration of entrepreneurship is more than proportionate for industries engaged in knowledge-intensive activities (Johannisson, 1998; Audretsch and Lehmann, 2005). Sorenson and Audia (2000, p. 426) maintain that, "dense local concentrations of structurally equivalent organizations increase the pool of entrepreneurs in a region, thereby increasing founding rates".

Clusters are long established in the literature as important places for learning, innovation and economic development at the regional level (Glaeser, 1999; Porter, 2003). The most well-known notion of an agglomeration to business scholars is the cluster concept of Porter (1990); but there is a host of other variants like industrial district or innovative milieu (for an overview, see Maskell, 2001). They differ in some respects but share in common a regional concentration of firms, in most cases small and medium enterprises (SMEs) and some supporting institutions.

In general, most research on geography of entrepreneurship deals with traditional production factors capital and labor; or, in more technology-oriented industries, venture capital and skilled human capital. These two input factors are indeed found to play a significant role in agglomeration literature. Hence, one would expect higher value-added activities to be localized in those existing clusters exhibiting features such as labor markets with experience specific to the requirements of new entrant firms; in particular, knowledge residing inside a cluster is a target of firms entering a cluster. However, in this case the good or service offered—software—is mobile and has very low physical transportation costs (however, there might be other transaction costs involved). Although one could argue that labor is relatively mobile in the service sector and even more so in high-technology industries like software, capital is still the input factor with the greatest mobility. It is precisely the localness of human capital that is responsible for knowledge spillovers—the theoretically most interesting yet under-researched agglomeration mechanism; most studies implicitly assume the existence of such spillovers. Analyzing the geographical nature of knowledge spillovers, it is well established that they are to a very large extent confined locally, or regionally at most (e.g. Audretsch and Feldman, 1996; Jaffe et al., 1993). A distinct feature of geographic clusters conferring a competitive advantage

to firms located within the cluster is the increased flow of information through a higher frequency of both formal and informal meetings.

In the case of Bangalore, like in other technology clusters, human capital is a critically important factor, in particular engineering talent (Tsang, 2005). An intuitive agglomeration channel is the local concentration of the labor pool. From an information and search cost perspective, it is easier for both parties to find the matching counterpart if both are located within the same geographical boundaries; even with the rise of the internet search costs cannot be fully eliminated. Hence, a concentrated labor market serves to reduce uncertainty for both supply and demand of labor. This concentrated labor market includes graduates entering the market fresh from university. In fact, Bangalore is home to the highest number of engineering schools and students, both absolute and relative to the population. Saxenian (1994) has found such labor mobility to be important in the growth of Silicon Valley. One of the factors implicit in labor mobility is the knowledge embodied in labor, hence knowledge spillovers. They are—again—implicitly assumed to be one of the positive features of a concentrated labor market, mostly because their measurement includes some methodological problem. So while human capital is principally assumed to be one of the most important location determinants for service firms (Hitt et al., 2001), it is particularly important in knowledge-intensive industries such as software (Tsang, 2005; Gardner, 2005; Colombo and Grilli, 2005).

H1: The probability of IT firm founding at one location is positively related to the local availability of human capital.

Supportive institutions like venture capital and law firms play an extremely important role for location of start-up firms in electronics related industries (Kenney and Patton, 2005). Given that start-up firms do not have access to formal capital markets, and do not posses the necessary collaterals for traditional bank lending, venture capital provides the appropriate risk capital (Powell, 2002). Interestingly, VC is regionally highly concentrated (Zook, 2004). Furthermore, (Powell, 2002) find a high concentration of both ideas and venture capital in biotechnology; moreover, these two crucial input factors of a knowledge-intensive industry are also correlated and highly connected through networks among VC firms as well (Castilla, 2003). Therefore, I hypothesize that the local availability of venture capital increases the probability of firm foundings at this location.

H2: The probability of IT firm founding at one location is positively related to venture capital locally available.

This paper shares some similarity with recent studies that combine cluster level with firm level processes (Folta et al., 2006). But whereas other scholars (Tallman et al., 2004) explicitly theorize the knowledge bases of firms as heterogeneous, the focus here is on the diversity of individual employees in firms and the firms' access to the resultant heterogeneous knowledge bases. In other words, the benefits of clustering differ between firms, in this case depending on relative cognitive

proximity and absorptive capacity of firms in a cluster. This conforms to recent studies with quite distinct approaches like, e.g., Alcacer (2003) who shows that most sophisticated firms do not locate in a cluster in order to prevent knowledge leakages. Hence, we expect these not to co-locate with less sophisticated ones. For instance, one anonymous large foreign MNE engaging in R&D for various sub-units from Bangalore, operates so secluded that there was hardly any contact information available other than fax. Unfortunately, during my fieldwork stay it was not possible to interview employees of this organization; but I was fortunate to speak with the director for quality of an affiliate of the same conglomerate. This isolated operation seems to stem from the fact that they fear knowledge leakage more than they hail potential spillovers from the cluster. Such a more pessimistic outlook on co-location as competition-enhancing (Sorenson and Audia, 2000) is reflected in studies of organizational ecology (see Carroll and Khessina, 2005, for a review). On the other hand, analyzing Canadian information technology firms, Globerman (2005) obtained strong evidence of locational clustering effects on firm growth while less on survival. Bell (2005) studying a different services industry—Canadian mutual funds—disentangles cluster from social network effects, with the latter being further subdivided in interpersonal and institutional ties; except for institutional ties he finds all effects to be of relevance for (innovative) firm performance.

Since one of the most prominent arguments for agglomeration benefits builds on the notion of knowledge spillovers, there exists a need to disentangle the associated mechanisms. In fact, Boschma (2005) claims that geographic proximity per se is neither a necessary nor a sufficient condition for collective learning. But it supports other forms of proximity to develop and thereby strengthens interactive learning and innovation (Maskell, 2001). Economic geography has broadened the range of concepts of proximity used by adding social, organizational and cultural (Lundvall, 1988) or cognitive and institutional (Boschma, 2005) proximity.

Social proximity enables a group to benefit from increased social capital and has been found a major characteristic among founding teams, even overcoming the requirement of some functional diversity (Ruef et al., 2003). Localized social networks are one mechanism to channel different types of resources necessary for nascent entrepreneurs (Johannisson, 1998; Sorenson and Audia, 2000). A particular kind of social network is based on ethnicity (Ruef et al., 2003; Tsui-Auch, 2005). Kalnins and Chung (2006) in their study on Gujarati hotel owners in Texas find a positive impact on firm performance measured as survival by co-locating with entrepreneurs belonging to the same ethnicity. In a broader interpretation common ethnicity is a form of social capital. I will turn to ethnicity as a location factor in the following section.

12.3 IT Clusters in India: The Role of Diversity

This section develops two additional hypotheses based on collection of original primary data. In order to emphasize the contribution of my own fieldwork, I will first give some basic remarks on the research design. Between November and December

2003 I visited the Indian Institute of Science, Bangalore and conducted 33 interviews with a sample of firms, universities and public sector entities. This sample was selected both randomly and through networking. The random sample is used in order to get a differentiated picture of the Indian IT industry in Bangalore, and has been selected from a directory of the National Association of Software and Services Companies (NASSCOM). The heterogeneity of the industry is reflected through my selection of SMEs as well as MNCs; furthermore, both foreign and Indian companies are represented. Moreover, there are hardware companies and software companies, the latter are engaged in service and product lines.

A chain of personal contacts through networks are deployed where it is necessary to learn from key decision makers (Bewley, 2002). The average length of an interview was 45 minutes, ranging from 20 to 150 minutes. Since most of the people interviewed were founders, CEOs or other senior executives, I decided to design the interviews in a semi-structured way, thereby leaving more space for open answers on part of the industry insiders. I relied on a questionnaire of more than 30 questions as a guideline to the interviews where applicable. The questions were centered on general company information, employee and recruiting, social networks, regional networks and international networks, and policy. In general, all questions have been touched through this kind of open discussion. Qualitative evidence from 16 semi-structured interviews with senior executives of small, medium and large Indian IT companies in Frankfurt conducted in October and November 2002 complements the findings from Bangalore and was used to triangulate information gathered on international dimensions of networks.

Many of the factors identified as influencing technology geographies in advanced economies seem to apply in principle to an emerging economy like India, too. For instance, the century-old history of education in the four southern states seems to be a leading indicator for the subsequent emergence of an IT industry here. This correlation can be closely mirrored by looking at the distribution of colleges in the four main regions of India which are significantly overrepresented compared to their population (confer Arora et al., 2004).

On the other hand, there are factors that seem to be idiosyncratic to different institutional contexts of emerging economies; some of them might even be special in the Indian case. There is ample evidence of emerging economies with underdeveloped product and factor markets exhibiting parallel or informal economies and scope for large integrated conglomerates (Khanna and Palepu, 2000). The motive put forward by Sorenson and Audia (2000) seems to have particular relevance in an economy in which the institutional framework seems different in terms of social safety nets. One idiosyncrasy of the Indian IT sector is that in the starting years domestic markets were not targeted; orientation of IT entrepreneurs was initially almost exclusively towards foreign markets. Moreover, entrepreneurs of these firms are found to be young and, hence, their intrinsic motivation a critical factor to rely on (Contractor and Kundu, 2004).

Findings from my fieldwork suggest an important role of socio-institutional factors for the emergence and growth of the IT industry as well as its geographical

distribution. Two key factors, as mentioned by my interview partners are assumed to be openness and diversity of a society:

> "One of the most important location factors is the very cosmopolitan nature of the city" (Co-Founder and COO, Indian SME)

> "Cosmopolitan nature has created mentality to connect with foreigners" (Director, Indian SME)

> "Innovation happens when there's a high level of diversity" (Co-Founder and Director, Indian MNC)

Diversity and openness are among the most crucial location factors for knowledge workers of the creative class (Florida, 2002). Florida, taking a multivariate measure to test for location factors relevant to Bohemians, he calls it the three T's—technology, talent and tolerance. In this work, I will specifically look at the correlation between technology on the one hand and some indicators of talent and tolerance on the other. While talent is relatively easy to assess given the data in India are much better than in other emerging economies, measuring tolerance becomes a more difficult exercise.

Openness at the firm level is in as much a necessary condition as a constant inflow of new knowledge and ideas is necessary in order to maintain a certain degree of innovativeness (Laursen and Salter, 2006). A cluster with a culture of openness helps each firm in it, because knowledge diffuses once it has entered the cluster through one firm (Tallman et al., 2004). Openness has been found to impact the overall climate of a location together with other amenities (Florida, 2002). According to my interview partners, Bangalore is

> "A place high tech professionals want to be part of" (CEO, MNC Spin-off, product company), with the

> "Quality of life at heart in IT" (Co-Founder and Director, Indian MNC).

In evolutionary theorizing, diversity assumes an important role in generating a variation of new ideas (Nelson and Winter, 1982), an important characteristic for innovative sectors like software and IT. Diversity can be seen as a sufficient condition providing access to the variety of novel ideas. In various literatures, different aspects and form of diversity have been theorized (Raghuram and Garud, 1996). Diversity has been established in the literature as a double-edged sword with both beneficial and harmful effects on measure such as innovation and firm performance (van der Vegt et al., 2005). Research on diversity and its impact has been mostly at the micro-level and predominantly for concepts such as gender or racial diversity (e.g. Richard et al., 2004). However, it also studied diversity of knowledge and ideas and its relevance for differences in economic performance of regions (Audretsch and Keilbach, 2004) or cities with respect to cultural diversity (Ottaviano and Peri, 2006).

The main contribution of this chapter is the inclusion of ethnic diversity—as inferred from the benefits of ethnic networks. Ethnic networks combine the positive characteristics of trust with diversity and openness thereby enhancing the social

capital of a region. The benefits from ties across different ethnicities or people from various regional backgrounds are that people in different regions develop different cognitive structures (Johansson, 2004, p. 47). These are advantageous because ethnicity allows for a latent yet trustful sourcing of information and knowledge. As a latent source the costs of maintaining strong network ties are relatively low, while the benefits of cohesive network can be fruitfully used. Cohesion stems from the common origin or ethnicity as a basis of high-powered trust (Appadurai, 1996; Kotkin, 1993). Moreover, ethnic ties can be particularly useful if and when they reach beyond the local realm (Rosenkopf and Nerkar, 2001), in other words, ethnicities are often spread over diasporas in distant regions such as from India to Silicon Valley (Taeube, 2004). Extending information flows beyond local or national boundaries greatly enhances opportunities to increase variety in firms' resource base. Stemming from heterogeneities in culture, institutions and other national idiosyncrasies, firms can get access to technological trajectories different from their home location (Ahuja and Katila, 2004).

Then, access to a much bigger pool of ideas can be achieved. In this ideal case, ethnic networks can simultaneously provide cohesion and structural holes. Given these beneficial features of ethnic ties, having a greater variety of such ties is desirable since it will improve knowledge flows even more. However, there are also drawbacks from too high a diversity level that moderate this positive effect, most prominently an increased risk of conflicts (West, 1995). Two plausible explanations for the beneficial impact of diversity to be found rather in developed countries are advanced: first, an institutional framework that mitigates conflict situations ethnically diverse societies are more prone to and secondly, a higher level of economic development in which diverse elements in the socio-economic structure reveal their complementarities (Alesina and La Ferrara, 2005). In other words, the benefits of diversity seem to come into effect only beyond some threshold level. Hence, I hypothesize the following:

- *H3a (Ethnic Diversity): The probability of firm founding is positively related to ethnic diversity.*

In a similar vein, another case of openness regards diversity of the workforce in terms of gender. India is a country with a high degree of masculinity (Hofstede, 1980) hence traditional role models would rather forbid women to become educated. The higher the share of women in education, the less traditional the respective state is, or in other words, more open and tolerant. Based on the argument made earlier of different cognitive structures one can infer positive effects of gender diversity on the idea pool as a resource. Assuming that most societies start with an unbalanced gender structure in which men dominate, I maintain the following related hypothesis:

- *H3b (Gender Diversity): The probability of firm founding is positively related to gender diversity.*

12.4 Empirical Corroboration: The Indian IT Space

In order to support the hypothesis developed above I will present some descriptive statistics on the Indian IT industry, supportive institutions and the respective locations in geographical space. Our variables of interest are the numbers of member firms listed in the directory of the National Association of Software and Services, NASSCOM (as of September 2003) in metropolitan areas and variables regarding the production factors labor, capital, and institutional framework.

12.4.1 Data and Sources

12.4.1.1 Variable of Interest

Our variable of interest is the number of member firms listed in the directory of the NASSCOM (as of September 2003) in metropolitan areas (IT). The number of such firms in the full sample is 854 dispersed over 35 locations; however, this sample has to be reduced by a number of firms. For eight firms no exact city location is mentioned; moreover, six locations with only one firm entry are deducted, not for having only one firm, but because they are rather small cities and lack a coherent set of other data. In one case (the state of Chattisgarh) the state has been recently spun off from another so that no other data are available. Another location (Chandigarh) is simultaneously the capital of two states; hence its seven firms will be removed. The remaining sample of firms to be used includes 838 firms concentrated in 27 locations. Once we account for the actual number of IT firms in these locations a concentration in even fewer cities is evident. Only 10 cities have more than 5 firm foundings at their respective location (see Table 12.1), two of which even belong to the greater agglomeration of the national capital region around New Delhi.

12.4.1.2 Explanatory Variables

There are three independent variables representing the components of a basic production function, i.e. capital, labor and institutions. For technology entrepreneurship a specific form of capital is relevant: venture capital; given that start-up firms do not have access to formal capital markets and do not posses the necessary collaterals for traditional bank lending, venture capital provides the appropriate risk capital (Powell, 2002). Similarly, with most technology firms being engaged in some form of knowledge-intensive industry, the most relevant form of labor is well educated human capital. One of the main findings from my fieldwork interviews was that Indian software firms not only look for well-educated manpower but they do also specifically target predominantly engineering graduates.

Regarding production technology or institutional framework the issue of identifying appropriate measures is a rather daunting task. Here, the focus is on two variables that have been identified as potentially influencing location decisions both in theory and practice; and that belong to the rather heterogeneous (and eclectic) construct of institutions: cultural openness and diversity. Openness has been found to impact the overall climate of a location together with other amenities (Florida, 2002). In evolutionary theorizing, diversity assumes an important role in generating a variation of new ideas, an important characteristic for innovative sectors like software and IT (e.g. Nelson and Winter, 1982).

Financial (Venture) Capital

While India has not (yet) reached the stage of big Venture Capital (VC) industries like US, Western Europe or East Asia, growth from 1998–2002 sees India with the highest increase of all countries with 82% (IVCA, 2004). Data for VC have been taken from various sources. The numbers of both VC investments and VC firms at state level in 1998 is from VCline. One potential endogeneity problem with VC in this context is that in India VC might have been attracted to already existing IT clusters. Unfortunately, at this stage we cannot control for this; but further research will aim at disentangling this effect. However, this might be limited to foreign VC investors who, interestingly enough, are almost entirely registered with the relevant Securities and Exchange Board of India (SEBI) under a Mauritian address, even though names like Citigroup Venture Capital International or Intel Capital suggest a different country of origin (SEBI, 2005).

Human Capital-Engineering Education

Probably the best indicator for the availability of human capital or a pooled labor market would be some kind of employment data (Dohse and Schertler, 2003). Unfortunately, such data are not available—yet; therefore I had to find some approximation for available labor force. As suggested in interviews, human capital is measured as university graduates, more specifically as engineering education, not the more generic literacy or university graduates. This is based upon fieldwork interview findings where in most cases the response on hiring practices was that specialized computer classes are much less valued than a broader technological education in engineering. Here, I deploy statistics from the Ministry of Education and the Census of India 2001. Interestingly, not only is the share of engineering enrolment higher in states that have a larger share of IT and high-tech FDI. More importantly, the difference between the share in engineering enrolment and the share in the national population is revealing (EDURENT). Similar to Arora et al. (2004), but on the more disaggregated state level, I find those states more actively involved in IT exhibiting higher positive 'education rents'.

Institutions – Openness and Diversity

It is rather difficult to find suitable variables representing diversity and openness. Two measures are used as approximations: ethnic diversity and 'gender diversity'. India is a multi-ethnic society with more than 15 official languages with different scripts, hence extremely multi-linguistic. This multiplicity of languages can be seen at the state level too. However in 1956, state boundaries have been redrawn according to ethno-linguistic boundaries. Thus, all of the major states have a main language and the people speaking it cover the majority of the population. As ethnic diversity we take the number of people groups speaking this main language in the state (from The Joshua Project, 2004). We maintain that the higher the number of different groups speaking the main language (or a dialect thereof) indicates a more diverse society (LANG). Ideally, we would directly measure the proportion of the respective groups in the overall population or at least weight the numbers obtained by the size of the group. Unfortunately, neither direct population measures are available nor is group size for all groups; therefore we need to take the simple count. In order to allow for the non-monotonic effect, ethnic diversity was modeled as a quadratic function (LANG2).

Furthermore, openness is measured by 'gender diversity,' or the percentage of female enrolment in higher education; not only in engineering but all university enrolment (ENROLFEM). Again, data come from the Ministry of Education and the Census of India 2001 (see Table 12.1). This can be interpreted as openness, because India is a country with a high degree of masculinity (Hofstede, 1980) hence traditional role models would rather forbid women to become educated. The higher the share of women in education, the less traditional the respective state is, or in other words, more open and tolerant. Moreover, there is some anecdotal evidence for cities such as Bangalore being very cosmopolitan, but there were no data available regarding cosmopolitanness in order to support these assertions.

12.4.2 Discussion and Limitations

One of the main surprises is certainly the ambiguous relationship between IT firm foundings and VC. There seems to be no clear-cut correlation between high number of IT firm foundings and VC availability in the state, whether measured as number of VC firms or projects. Possible explanations would argue that either the Indian VC industry is not—yet—as relevant as the US counterpart. As mentioned above, there is more than anecdotal evidence from my interviews and in business media of VC lagging behind and following technology industries in countries such as India. Alternatively, the importance of VC might be overstated for the specificities of Indian IT. Some argue that Indian IT firms do not involve actual risk-taking; since they are largely based on scale by amassing relatively cheap software programmers to write code, hence do not require venture, or risk capital for that matter. I did not discuss this issue in detail, but yet again, there is some anecdotal evidence in support of

Table 12.1 FDI, human capital and venture capital, diversity and openness in Indian IT

City	Inhabitants	IT firms	FDI high-tech 1985–2004	Nat'l share of engg. in state in state	Share of state enrolment less share of state population	No. of VC projects in state	No. of VC firms in the state	No. of groups speaking main language	Enrolment of women in state
Mumbai	12.596.243	152	29	27,5%	17,95%	167	21	82	41,0%
Kolkata	11.021.918	32	3	3,2%	−4,72%	23	2	140	39,4%
New Delhi	8.419.084	108	29	–	−1,35%	27	12	10	46,0%
Chennai	5.421.985	92	24	12,8%	6,74%	121	3	87	45,1%
Hyderabad	4.344.437	78	18	14,6%	7,12%	92	1	140	39,3%
Bangalore	4.130.288	182	31	7,9%	2,73%	106	9	175	40,9%
Ahmedabad	3.312.216	15	1	7,7%	2,76%	54	1	143	44,2%
Pune	2.493.987	57	8	27,5%	17,95%	167	21	82	41,0%
Lucknow	1.669.204	2	0	5,8%	−10,46%	26	2	126	38,4%
Nagpur	1.664.006	5	0	27,5%	17,95%	167	21	82	41,0%
Jaipur	1.518.235	5	0	1,1%	−4,48%	11	0	43	32,3%
Cochin	1.140.605	4	1	5,6%	2,42%	15	0	96	60,0%
Vadodara	1.126.824	4	2	7,7%	2,76%	54	1	143	44,2%
Indore	1.109.056	3	1	4,8%	−1,10%	12	0	46	37,2%
Coimbatore	1.100.746	5	0	12,8%	6,74%	121	3	87	45,1%
Bhopal	1.062.771	5	0	4,8%	−1,10%	12	0	46	37,2%
Trivandrum	826.225	7	1	5,6%	2,42%	15	0	96	60,0%
Visakhapatnam	1.057.118	1	0	14,6%	7,12%	92	1	140	39,3%
Nasik	725.341	1	0	27,5%	17,95%	167	21	82	41,0%
Rajkot	654.49	1	0	7,7%	2,76%	54	1	143	44,2%
Mysore	653.345	1	0	7,9%	2,73%	106	9	175	40,9%
Ghaziabad	511.759	1	1	5,8%	−10,46%	26	2	126	38,4%
Jalandhar	509.51	1	0	2,7%	0,36%	7	0	99	52,7%
Tuticorin	280.091	1	0	12,8%	6,74%	121	3	87	45,1%
Noida	146.514	41	3	5,8%	−10,46%	26	2	126	38,4%
Gurgaon	135.884	33	1	1,3%	−0,73%	20	0	16	41,0%
Gandhinagar	123.359	1	0	7,7%	2,76%	54	1	143	44,2%

this argument in my interviews. In a similar vein, one could expect business groups or other traditional sources of capital such as extended family to be more relevant for full-blown start-ups and conglomerate diversification, respectively (Khanna and Palepu, 2000).

An interesting direction for future research in this regards is the actual mechanism of transnational VC, two issues in particular: firstly, how does a normally highly localized industry function in a transnational context? and, secondly, how important are ethnic ties between VC firms and entrepreneurs?

The relationship of human capital, more specifically engineering enrolment, is much clearer. The cities with high numbers of firm founding are located in states with high numbers for enrolment. This relationship becomes even starker when one looks at the next column which shows the education 'dividend' the overrepresentation of enrolment share compared to the population share; here the states with more foundings show a positive percentage, whereas the less successful ones show negative numbers. This effect is less clear only for New Delhi, which can again be ascribed to a NCR effect. Surprisingly, Calcutta, which is known for its high estimation of education, lags behind in both education and IT foundings. This is not surprising because almost every interview partner mentioned engineering talent as one of the single most important factors of their respective company. Again, explanations point toward a somewhat biased interview finding not representing the entire spectrum of Indian IT which potentially includes less risk-taking and less innovative firms as well.

On the other hand, it is interesting to find ethnic diversity as the single most important and robust explanatory factor. But it was expected, since the cosmopolitan nature of Bangalore was part of the main inductive reasoning stemming from my fieldwork. It is the argument from evolutionary theory that heterogeneity and diversity is positive in as much as it enhances variety of ideas (Nelson and Winter, 1982). Finding support for this hypothesis turns out nicely. In this way the chapter also contributes to the literature on creating heterogeneous resources (Ahuja and Katila, 2004).

Similarly, gender diversity has the same theoretical foundation. But, both measures could also be explained by a certain regional culture (Romanelli and Khessina, 2005). One could argue that it is precisely a socially more coherent and stable culture that is needed to allow for an influx of new, external ideas which makes some regions more successful than others. In other words, a social capital-based explanation could be employed to argue for a balanced population structure.

One limitation is certainly the theoretical issue of finding the most appropriate variables to be employed in a model. In particular, the variables pertaining to the institutional setting are somewhat arbitrary; but these variables constitute the empirical novelty of my research. I argue that they are reasonably close to other proxies that might have been more appropriate but unfortunately could not be gathered, e.g. detailed socio-demographic data on a region's population in order to grasp ethnic diversity of the population in one location; or foreigners or foreign firms to approximate tolerance of a region.

As regards the empirical strategy, a couple of shortcomings concern availability of data. For instance, there is one specific problem regarding the geography of India per se. This problem lies in the geography of India and can be explained by the existence of a so-called National Capital Region (NCR) surrounding the city-state of New Delhi. As such, it consists in the fact that there are two neighboring states in the NCR, both of which exhibiting a notable number of IT firms in the cities of Noida and Gurgaon, respectively. In some studies, this region has been taken as one entity. In order to check for robustness of the suggested relationships, I thus conducted a series of analyses which is not reported here, aggregating all count data for the two locations in the NCR together with the capital New Delhi itself. None of the results changes in sign or significance level thereby further supporting the results reported here. Robustness of the data has been checked this way because, arguably, New Delhi exercises more influence on these two cities than their respective states; essentially, they are satellite cities of New Delhi. Hence, viewing NCR as one geographical entity or rather economic space seemed appropriate. Arguably this makes a lot of sense, for both of the smaller locations are far away from other urban agglomerations in their respective states and can be best described as satellite towns or even suburbs of the New Delhi Metropolitan Region (although they officially belong to other districts, see Census of India, 2001). Stemming from this ambiguous geography in a politico-economic sense, there is some discretion in allocating endogenous variables to exogenous variables. Obviously, this could have resulted in a misallocation which might explain the surprising weakness of variables such as VC, for relatively strong locations of the NCR are allocated to relatively weak states in the North. Further research requires some refined examination of raw data.

12.5 Conclusion

This chapter is a first step trying to better understand and measure socio-cultural determinants of geographical concentrations of high-tech industry entrepreneurship in emerging markets exemplified by the Indian software industry. The main contribution of this chapter is certainly the introduction of a hitherto neglected topic—the influence on regional development of cultural openness in terms of an ethnically diverse and progressive society. While other types of diversity have been studied before ethnic diversity has been somewhat neglected. It has been shown that support factors established in the literature such as human capital play an important role in location decisions of technology firms; unexpectedly financial (venture) capital does not. In addition, hypotheses on other explanatory variables have been developed from interview fieldwork. It has been argued that diversity of a regional culture in terms of ethnicity and gender can contribute to a region's economic development and thus the firms located therein. These theoretical arguments are supported by descriptive statistics and anecdotal evidence on the location of the Indian IT industry and the supportive institutional environment. Findings include the usefulness for

firms in the clusters of ethnic diversity. Ethnic ties combine positive characteristics of both cohesion and structural holes thereby enabling a trustworthy connection to non-local sources of information, knowledge and ideas. Therefore, a variety of such ties is beneficial for clusters and firms therein.

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Part IV
Conclusion

Chapter 13
Dynamics of Entrepreneurship and Economic Growth

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13.1 The Background

Technological changes have been at the apex of economic growth for a long time. From about the 1980s the pace of knowledge development and associated technological transformation has been sensational. The major drivers of these changes have been the information technology, biotechnology and nanotechnology. To absorb these technologies into the mainstream of production, distribution and coping with the requisite changes in the economic and social organization have been the main themes of theoretical as well as practical investigations. Given the current state of assimilation of these technologies by various countries it may not be possible to visualize any steady state in the near future. Perforce the investigations must refer to transitional dynamics of the relationships between knowledge generation, its utilization in production and organization of exchange.

The major theme in economic analysis of recent vintage concerns the absorption of new knowledge. An entrepreneur is therefore conceptualized as one who utilizes this knowledge to make production of goods and services possible. There are at least three levels at which economic analysis is progressing.

The first consideration is about the appropriate conceptual background. For most part the choice has been the steady state in endogenous growth theory. It has the advantage of setting up a direct relationship between entrepreneurship (usually an ex post facto measure like the investments made in small manufacturing enterprises (SMEs) has been utilized as the measure of entrepreneurship) and economic growth. The other necessary institutional adjustments are conveniently subsumed under the ceteris paribus clause. Implicitly the assumption is that such changes will be made automatically once the imperatives of economic growth are acknowledged.

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Let me elaborate. First, individuals as well as nations will grow only to the extent they can perceive opportunities that exist in their environment and translate them into activities that result in economic growth. The Schumpeterian perspective suggests that creating opportunities and designing institutional mechanisms to foster growth should also be a part of human endeavor. The causation may be in both the directions. In either case institutional arrangements have an important role.

Theories of economic growth, and for that matter economic theory in general, seem to run the course in the reverse direction. Early theories of economic growth, exemplified by the Solow-Swan model, assumed the existence of friction free operation of institutions and postulated exogenously defined technologies, rate of growth of population and propensity to save. They also assumed that information is freely available to everyone and can be harnessed at zero transaction cost. It is only much later that it was acknowledged that the poverty of nations is basically due to the information asymmetry and institutional rigidities. This is reflected in the recent quest for globalization, free trade and so on.

Endogenous growth theory, as outlined by Solow and Romer, acknowledged technological progress created within the system (as opposed to being given exogenously like manna from heaven) as an important driver of economic growth. If this is broadly interpreted, even institutional transformation to bolster technological development and absorb its activities can be viewed as the essence of entrepreneurship.[1]

Second, there has been a focus on the organizational changes required for the efficient absorption of new knowledge. This may cover the entire range of the value chain including acquisition of materials, finances and so on. Clearly, information technology brought in its wake new financial instruments, organizational possibilities and other far reaching changes. Economic analysis is trying to come to grips with these as well.

Third, there is an acute recognition that the knowledge economy has differential impacts on different industries and segments of society. In the industrial sphere there is an increasing acknowledgement that the growth of the industry and of the firm which is a part of it is now conditioned by the capacity of its management to perceive and react to threats as well as opportunities. Spinoffs, mergers and acquisitions have had destabilizing dynamic effects on economic growth. This phenomenon is of course not new. Chandler (1990) eloquently documented the fall of the US steel industry and that of the German glass industry among others. Disequilibrium dynamics, both in its theoretical form as well as the empirical context, has been deemed necessary.

Two factors have been at work in the linkage between entrepreneurship and economic growth. First, there have been significant risks involved in investments. In particular, the following dimensions are noteworthy:

1. In the early stages of knowledge development there is no assurance that new knowledge can be developed to yield a product of value. It may not be possible to scale up laboratory technology to industrial level efficiently.
2. The products may fail at the regulatory stage.

3. The products may not succeed in the market (the consumer may still prefer conventional products of chemical technology, say, as opposed to biotech products available on the market). Investments are then sunk in the sense that there are no alternative uses.

Second, entrepreneurs face information asymmetry. This has the following aspects.

1. Large firms do not have the organizational culture to develop new knowledge and/or assimilate it without outside assistance.
2. Conventionally, firms employed scientists trained in the university to assimilate new technology. But there is an inadequate supply in the context of new technologies.

Clearly, the pace of change and the nature of response have been different across industries within a country as well as across countries. Some strategies have been more successful than others. Hence, understanding the most efficient progress in different directions has become essential. Information asymmetry experienced by any one country in this respect can be quite a disadvantage.

Given the relative immobility of some factors of production, especially labor, it is necessary to conceptualize other entrepreneurial actions for the generation, acquisition and utilization of knowledge to maintain competitive advantage and ensure growth. Network organizations, WTO agreements and so on are essentially a response to such needs.

This is the backdrop against which the workshop was set up to understand the relationship between entrepreneurship and economic growth. Some papers were purely theoretical, some were set in a macroeconomic perspective and several of them dealt with microeconomic level empirical reality.

13.2 Lessons from the Chapters

Two studies, by Fier and Heneric and Rao, considered the issue of generating new knowledge and translating it to industrial level technology. Both in Germany and India the government took up the entrepreneurial function.

Governments tend to set up agencies to encourage knowledge development whenever

1. The risks involved are large
2. External economies cannot be internalized by private firms (may be in the form of defense requirements in some cases)
3. Investments are too large and have the nature of sunk costs.

However, in the initial stages governments do not have the organizational capabilities to perceive the desirable activities. They also take too much time to streamline the decision making process. As such they tend to miss out on some worthwhile activities. It is also true that once they acknowledge it and finance some activity

the resulting institutions have a tendency to make efforts to perpetuate themselves even after the initial purpose for which they have been set up is lost. Similarly, it is difficult to spinoff activity to the private sector even when it is more efficient. These problems have been documented for both Germany and India.

The problem of the emergence of SMEs and private entrepreneurship, to take up industrial activity based on emerging fundamental knowledge, experiences similar problems. Inevitably the governments intervene at various levels. The agricultural extension services and the production of life saving drugs are glaring examples. However, there must be an optimal balance between the public and private partnership at a point of time as well as dynamically. Conceptual economic models can suggest efficient organizational mechanisms. But in practice there are many more rigidities. As a result, the observed dynamic growth paths may reflect under performance or overshooting efficient targets. Reducing such institutional constraints may indeed be a formidable task. The experiences of Germany and India are similar even in this context.

Consider the studies by Sanders and Keilbach and Keilbach, Bonte, and Audretsch. They are based on the steady state characterization of endogenous growth models (see Romer (2001, Ch. 3) and Aghion and Howitt (1999, Ch. 1) and some original extensions by the above authors). The authors generally claim support for technological knowledge leading to entrepreneurship and in its turn to growth. I have a feeling that the intervening institutional arrangements have been taken for granted.

There is a temptation to speculate that educational level is the intervening variable between knowledge and entrepreneurship. For, after all, India could virtually conquer the global IT industry because it has the mathematically educated manpower. Keilbach and his co-authors did not say much about this. However, we have two strong evidences from India. Kumar et al argued that migration and population structure mattered. The levels of educational attainment per se do not have any such effect. Similarly, Taube found that ethnic diversity and geographic dispersion are the key drivers. This comes as a bit of a surprise. However, note the following. Only workers with a particular skill will be suitable for the IT industry. They are the people who move to where the action is. Given a level of education and skill they prefer working with their own people (language, ethnicity etc).

Rajeev argued that the link between entrepreneurship and growth depends on government policy because the small entrepreneurs are risk averse. I cannot subscribe to this. For, the evidence in Chaudhury (1999) is more persuasive. He argued that SMEs succeed only when there is a dynamic interaction with large firms in the transfer of technology, designs and related informal knowledge and an assurance of market from large firms. This is so because the SMEs depend on larger firms for technological assistance as well as for a market for their product. It should also be noted that the ultimate interest in the study of entrepreneurship is not the growth of any one of the SMEs but instead in the growth of the industry at large.

I, for one, am not quite convinced about the definiteness claimed for the causation between entrepreneurship (SME start up) and growth either. For, once again, the efficiency of the intervening institutions crucially determines the technology

absorption and growth of the industry. Further, the interaction of this supply process with the demand side cannot be underestimated.[2]

On the whole, it may be argued that scholars on both sides acknowledged the relationships between knowledge transfer, technological development (the entrepreneurial function) and economic growth. There are some differences with respect to the level at which these relationships should be examined. My own feeling is that industry specific studies may be eventually more pertinent for the design of policy.

One thing is clear. There was no a priori specification of the issues that will be debated at the workshop. Hence, the participants raised a variety of issues without attention to comparisons on both sides. However, in the end, the workshop could discover a commonality of purpose. Greater clarity in the identification of the issues has the prospect of eliciting studies that enable us to make more meaningful comparisons.

Global transfer of knowledge, technology transfer and foreign direct investments will become a reality only with such efficient dissemination of information.[3]

13.3 Agenda for the Future

Now that we understand each other better, we may consider the directions in which further collaborative work will be fruitful.

First, there is no harm in doing comparative studies on aggregate growth models. To the extent I am aware of it, such an exercise for India is still due. However, the differences across industries are very glaring and as such aggregate models cannot capture the reality in its essential detail. My feeling is that the Romer model can be extended to accommodate this requirement of modeling the industry level growth process. The major addition must be towards an open economy model. Similarly, the model of Bonte and Keilbach is amenable to more general interpretation in this direction.[4] I would like to see collaboration between someone at Max Plank and in India to achieve this before embarking upon extensive empirical work in both the countries. I recognize that this is a large agenda. One workshop can then be conceptualized in which the industry level studies will be put in a common framework for evaluations. There is no doubt that both Germany and India will have much to learn through such joint efforts.

Second, the problem in India has been the differences in language and culture across states. The nature of integration that would encourage entrepreneurship is not explored as yet. Germany is facing a somewhat similar problem both in its integration between the east and the west as well as its assimilation with the European Union. For a beginning, therefore, it may be worthwhile to disaggregate the endogenous growth model estimation to regional level.

Third, knowledge transfer is the crux of the problem in the international diffusion of emerging technologies. With the emergence of the recent patent regime and WTO regulations there is an important question about how global entrepreneurship can

contribute to knowledge diffusion and technology transfer.[5] A more general open economy endogenous growth model is perhaps in order. Some thought should be given to developing this and deriving lessons for different countries.

Fourth, there are several institutional differences between India and Germany. In particular, there are differences in the legal system and policies and procedures for knowledge and technology transfer. How these affect entrepreneurial growth and what can be done to make more efficient use of resources is an issue that deserves examination by both sides.

Fifth, issues involving environmental and ethical considerations place a limit on the global flow of knowledge and technology. This may impede entrepreneurship to some extent. Arriving at a consensus to achieve optimal economic growth is a necessity.

Sixth, the phenomenon of spinoffs is universal. It has very important implications for the disequilibrium path through which a steady state endogenous growth process materializes. The patterns of diversification and spinoffs are different across countries. A conscious effort to disentangle the factors affecting such decisions and their effects on optimal economic growth will have abundant economic value.

On the whole I would suggest that a good beginning has been made. The next time around the workshops can be more focused and policy oriented. In the long run both the parties stand to gain from such interaction.

Notes

[1] I am inclined to credit Enthoven (1960) as the earliest pioneer of endogenous growth theory. For, he demonstrated the role of financial intermediation in the process of economic growth. Of course, in the present context I am referring to a more far reaching institutional set up.

[2] The experience of the IT industry is perhaps fortuitous. The biotechnology industry is going through a different transformation process. In particular, some changes in technology may merely involve a new way of doing old things rather than cater to any new needs. Similarly, the new technology may displace old firms in much greater numbers in comparison to the new firms that it creates.

[3] I am reminded of the following. The Infrastructure Development Corporation of India (IDFC) makes large investments in infrastructure. The MD thought that it was his duty to convince the shareholders that his decisions were wise and calculated. To this end he commissioned studies with the basic purpose of assimilating the requisite information and making it known to the shareholders.

[4] Note that there is a wide spectrum of models of growth of individual firms. Some aspects of these models are pertinent in the present context as well. However, industry level endogenous growth models will have a very different emphasis.

[5] Suppose an individual in a developed country discovered knowledge to treat some disease. Suppose this disease is not common in that country. Then he will not take up entrepreneurial activity. He will also block someone else in a developing country where the disease is prevalent to take it up, because he has patent rights. Global entrepreneurship can be encouraged only if there is an appropriate form of compulsory licensing.

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