Jack Buffington

Frictionless Markets

The 21st Century Supply Chain

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To Dad, you've always been my hero.
To Kate and Marin, may this future be yours,
Love Dad.

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Friction = Jobs

The Problem of Technological Unemployment

No issue has been more on the minds of Americans in the twenty-first century than the economy, and more specifically, that of jobs and unemployment. As is shown in the U.S. Gallup Poll data in Fig. 1.1 (Gallup 2014), the economy and jobs are the top issue, with no other issue even close in importance. Some aspects of the economy are doing rather well: financial markets continue to ascend to high levels, with the Dow Jones Industrial Average reaching record levels, surpassing 18,000 at the time of this writing in February of 2015, versus fewer than 8000 in 2009 during the recession. Why are the stock market and other financial indices rising while wages are falling, lowering the average person's standard of living? The answer is clear, but not very well known: accelerating advancements in technology continue to provide greater benefit for businesses to invest in capital rather than labor.

This issue of technological acceleration and its adverse impact on labor is nothing new; at the onset of the Great Depression of 1929, John Maynard Keynes wrote an essay titled, "Economic Possibilities for our Grandchildren" to address this economic imbalance that he considered only a "temporary maladjustment." To Keynes, the problem "of our discovery of means of economising the use of labour (is) outrunning the pace at which we can find new uses for labour", which led to "a new disease of which some readers may not yet have heard the name, but of which they will a great deal in years to come—namely, *technological unemployment* (Keynes 1963)". Keynes began writing this essay prior to the start of the Great Depression in 1929, noting an "economic problem" caused by technological change and economic structural instabilities. At the time, there was a path of technological innovation without an ample economic structure to lead to stability in market activities that was a major reason leading for the 1929 Crash. Through the proper use of policy, Keynes believed that a new economic structure could lead to a future (that of his grandchildren, who are us) where technology would be the solution, not cause of the *economic problem*. The economic possibilities for us, Keynes' grandchildren, would be a scenario "when these needs are satisfied in a sense that we prefer to devote our energies

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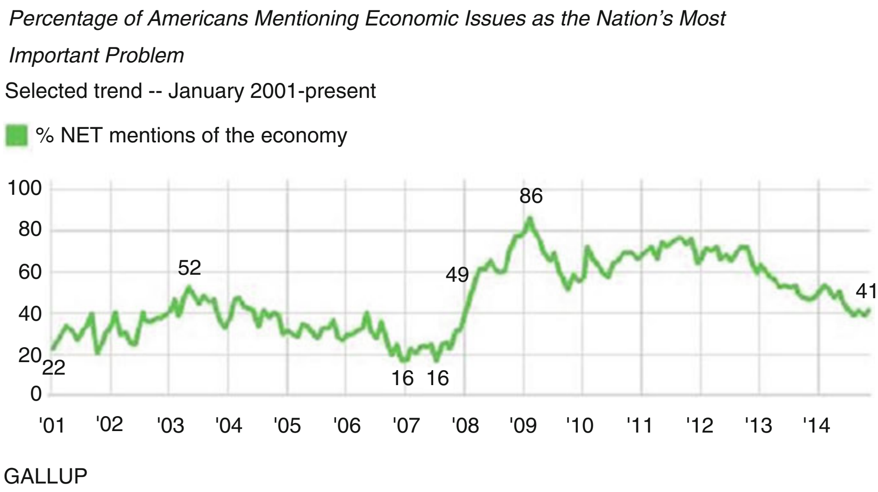

Fig. 1.1 Economy as most important issue (*Source*: Gallup 2014)

to non-economic purposes" (Keynes 1963). To Keynes, an advancement of technology should lead to the advancement of all of our "basic needs", a post-economic *age* to be ushered in where each of us would be required to only work 15 h a week, allowing for the remaining time to be used as we please, including to improve society. Of course, this era never came to fruition.

This idea of a *post economic age* has either led to the anticipation of technology freeing humans from labor, proposals to slow down the progress of automation, or both. In 1989, author E.F. Schumacher called for a paradigm shift beyond economics to a *post economic age* in his book, *Small is Beautiful*: *Economics as if People Mattered*, using the term *enoughness* and a call for "an appropriate amount of technology." To Schumacher, technology was moving too fast, leaving a need for economics to even the playing field of people over progress. This same issue was addressed 20 years after Schumacher's book with Martin Ford's work, *The Lights in the Tunnel*, asking "where will be the jobs when automation completely takes over?" Ford's answer to this question was a proposal that provides basic income from the government in return for an individual's community service for the good of society. This concept of a *leisure society* remains popular today, as is shown by the European Citizen's Initiative (ECI) for Unconditional Basic Income (UBI, shown below in Fig. 1.2) that promotes a guaranteed wage for all in order to provide enough to cover day to day expenses. A growing resentment amongst Americans and Europeans in respect to this "labor problem", such as the *Occupy Wall Street* movement, demonstrates an increase in anger toward technology and capital, and a promotion of social welfare solutions to this problem. Although protestors may not exactly articulate the problem being one of rising technology and decreasing labor, the owners of capital are capturing more of the world's income, and the share going to labor is falling (The Economist 2014a). There may not be a consensus in regard to what to do about this societal problem, but it should be clear to all regarding the rising intensity of the

Fig. 1.2 The "visible hand" of the government

EUROPEAN INITIATIVE FOR BASIC INCOME

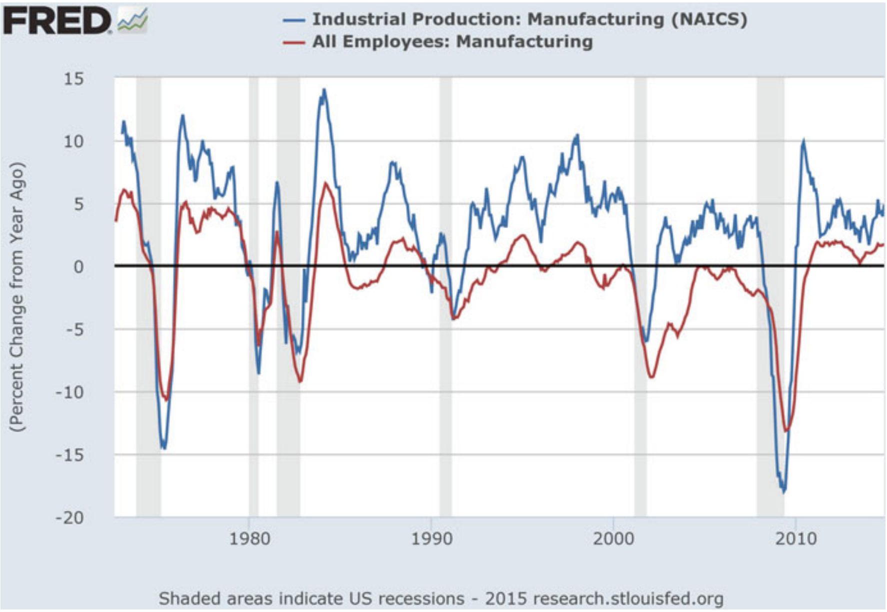

Fig. 1.3 The "great divergence" (*Source*: Saint Louis Federal Reserve 2015)

situation, especially as technological advancement leads to lower capital investment requirements, further impacting labor markets.

The purpose of this book is to propose an alternative model of radical change to our economic structure and markets to address the problem: instead of proposing limits to technology advancements in order to halt its impact on labor, or a larger government social safety net putting *an end to work*, I am proposing that we develop a new economic model that will complement the benefits of accelerating technology to transform markets into a twenty-first century frictionless supply chain model. This solution of *frictionless markets*, or an increasing lack of need for labor in economic markets, accepts this growing problem of *technological unemployment* will continue to accelerate, rather than considering it to be a myth, or "temporary maladjustment." MIT professor Andrew McAfee addresses the *myth of the* "*myth of technological unemployment*", illustrated in Fig. 1.3 (McAfee 2013); manufacturing output continues to grow strongly over the past 40 years while there is an undeniable flat to declining labor market. The conclusions from this data are obvious: productivity gains in manufacturing (and now so in services and government) are being achieved through a capital investment in technology as an efficient replacement to the use of labor in the market. This trend is not just happening in the U.S., but is occurring in developing, manufacturing dependent economies, such as China, as well. In a study conducted in 2013 of 702 detailed occupations, 47 % of total U.S. employment is directly at risk (Frey and Osborne 2013) due to automation, and it appears as if this problem will only grow in intensity. To solve this economic problem of unemployment and *underemployment* as a function of accelerating technology that leads to automation, we must acknowledge *technological unemployment* as a foundational economic problem, but also not react inappropriately through attempting to slow technological change, or increase social welfare programs.

"18 Computers" and "Bullshit Jobs"

Legendary scientist Freeman Dyson tells a story of John von Neumann, the brilliant twentieth century mathematician who developed one of the first computers that was used in his development work on the hydrogen bomb and weather forecasting. According to the story, von Neumann was asked by a government official just how many of these computers does he think will be demanded worldwide once its usefulness was understood; looking at the computer, which took the space of an entire room, von Neumann's answer was "18". Futurist Ray Kurzweil makes a comparison between the computer he used 35 years ago in the MIT lab (that was generations ahead of von Neumann's machine) to the ones of today that fit in our palms that are "1,000 times more powerful, and over 1 million times cheaper" (Information Week 2010). The computers of the mid-twentieth century that took up an entire room and were prohibitively expensive were not considered as a useful invention until processing power and cost allowed for widespread ubiquitous use. As these devices become cheaper and more powerful, they are increasingly useful in many personal and commercial applications, many which are displacing workers.

Moore's Law, shown in Fig. 1.4, demonstrates how computing power has doubled every 2 years, a rule that would have been inconceivable for von Neumann to understand 75 years ago! Who could have predicted that today's computers would fit in the palm of our hands, and change the nature of business, as is occurring today? And we have seen nothing yet: Kurzweil predicts that soon these computers will be the size of a blood cell and enter our bodies to perform functions we today can scarcely imagine (Information Week 2010). For those who believe this is science fiction, think about what is reality today that was inconceivable even 30 years ago. What does this mean to the businesses of today and the future? It means that as technology continues to accelerate exponentially, it will continue to become mainstream in more business functions, putting downward pressure on wages and new hires. This is an inescapable reality that we must wholly accept.

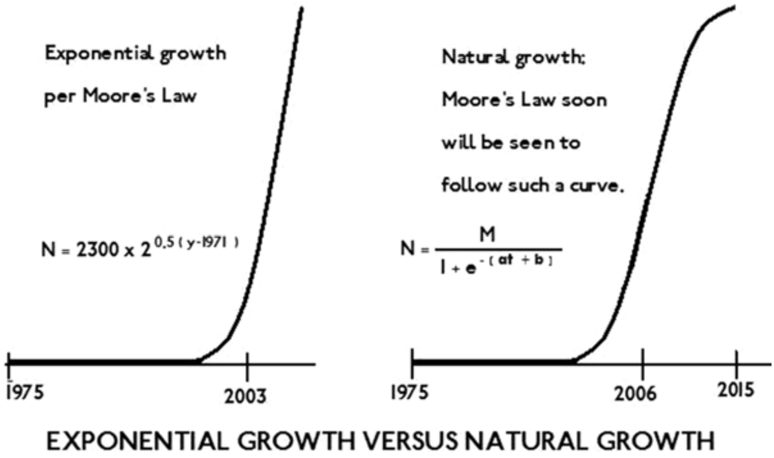

Fig. 1.4 Moore’s Law (*Source*: indymedia.org)

If technology, particularly computers, continues to progress in this trajectory, as outlined in Fig. 1.4, there is the possibility, in the words of futurist Vernor Vinge, “we will (one day) have the means to create superhuman intelligence, and the human era will be ended” (Vinge 1993). The term used for this potential future phenomenon is *technological singularity*, and those who subscribed to this future state are called “Singulartarians”. Perhaps the best known of these individuals is Ray Kurzweil, a genius by anyone’s definition, believes humans will have to deal with the *technological singularity* only by merging with machines because if we don’t, we will become obsolescent in the face of its superiority. Some consider Kurzweil to be a crackpot to consider a *technological singularity* by 2029, but Kurzweil’s theories have a way of coming true, and even if only partially correct, it will lead to a transformation of science and technology that will radically change our economy and supply chains.

Regardless of this technology trajectory path into the future, it is a consistent pattern that technology always moves faster than society is ready for it. Twenty years ago in 1995, a nationwide manhunt was underway in America for a *Unabomber* suspect who was killing targeted individuals through sending bombs in the mail. At the crescendo of his public terror campaign, Ted Kaczynski offered a deal to the authorities: if the New York Times and Washington Post published his 35,000 word essay in their newspapers, he would halt his bombing campaign. Both papers obliged, and the public read his manifesto that discussed technology in society, noting the differences between “small scale” technology as “useful and organizationally independent” from a socio-technical society, and “large scale” that is “organizationally dependent”, and only functional through a large controlling societal structure. Over his 17 year reign of terror, the Unabomber sent 16 bombs that killed 3 people and injured 22, using tools of violence that practically nobody would support; yet his essay “Industrial Society and its Future” has a surprisingly large following, even those who would not classify themselves as anarchists; the mainstream foxnews.com posted an article titled, “Was the Unabomber Correct” (Ablow 2013). As technology accelerates, we become more fearful of it, expecting it to harm us more and help us less. The question is whether it is the technology that is harming us, or rather an improper structure of its place in society for optimal benefit; our goal for the future is to develop systems that enable us to take advantage of technology rather than being fearful of it.

Yet the voices of discontent are becoming more ominous, to the point of becoming dangerous and even conspiratorial. Such a voice is social activist David Graeber, an economic anthropologist at the London School of Economics. Graeber has not only called for the fulfillment of Keynes’ vision of the 15 h work week, he has hypothecated that the exclusion of this “15 hour work week” is due to the government and capitalists seeking to keep the masses distracted away from the broader issues of importance. “Bullshit jobs”, as Graeber calls them, are the pointless, meaningless jobs “that a profit-seeking firm is going to do (to) shell out money to workers they really don’t need to employ” (Graeber 2013). According to Graeber, “the answer clearly isn’t economic: it’s moral and political. The ruling class has figured out that a happy and productive population with free time on their hands is a mortal danger. And, on the other hand, the feeling that work is a moral value in itself, and that anyone not willing to submit themselves to some kind of intense work discipline for most of their waking hours deserves nothing, is extraordinarily convenient for them” (Graeber 2013). Graeber, one of the leaders of the *Occupy Wall Street* movement, is a leading voice of frustration that indirectly caters to violent fringe elements who believe private multinational corporations (MNCs) are intentionally hiring workers in order to win a class war battle. In this book, I will acknowledge the concept of the *bullshit job* myself, but not as a function of some governmental/multinational corporate conspiracy, but rather through the form of feckless, outdated, large organizational inefficiency; in my model, these jobs will eventually disappear in near totality, not be propped up for social control.

Whether one believes that technology and corporations are good or evil, almost everyone agrees there is a significant structural problem in our present day economic system that must be fixed soon, or civil unrest will continue to grow. Thomas Piketty’s book, *Capital in the 21st Century* addresses today’s inequality with mounds of supporting data, concluding that a return to “patrimonial capitalism” that must be accomplished through government intervention as soon as possible, or it will face a blowback of political instability. *The Economist* has labeled Piketty as “A Modern Marx”, given his focus on wealth concentration and inequalities to be fixed by government intervention. There are many voices responding to this feeling of disenchantment; Piketty’s calling for government to solve the problem, Graeber believing the government and business in being conspiratorial to the people, and an anarchist like Kaczynski viewing technology as a tool of the mega organization to support large scale control over the population. In this book, I will propose a twenty-first century supply chain model from a different perspective: a model that uses technology that leads to the power of the individual, not larger organizations. This approach will be supported through concrete examples in business that addresses the entire supply chain, from materials, production, consumption, and post-use.

The Friction Paradox and 'the Two Big Os'

In nature and in business, friction creates traction, which is an important facet of life. In nature, friction occurs when two objects come in contact with one another, such as your shoes on the asphalt when running a marathon, or a snake's bottom scales to the ground. The rougher the object, the greater its frictional force; too much or too little friction impacts the work able to be achieved. There's a need for balance in both nature and business markets for growth to occur; both frictions and lubricants are necessary. Today, our outdated twentieth century economic structure is out of balance with the trajectory to which technology is taking us. Starting back in the eighteenth century, Adam Smith's foundational economic work, *An Inquiry into the Nature and Causes of the Wealth of Nations* (1776) addressed the issue of *market friction* that existed at the time: an inability of capital, labor, and technology to move forward to create economic success. In the eighteenth century, there were many structural forces that prohibited the free flow of supply and demand that was required in a market system. Essentially, Smith advocated the *invisible hand of the market* to rule, enabling markets to reach equilibrium through the proper use of capital, labor and technology for supply and demand to be in equilibrium; he advocated a reduction in friction, which is what I'm proposing in this book.

Adam Smith's idea of a reduction of friction led by the invisible hand of the market of supply and demand would prove itself useful up to the end of the nineteenth century when technology began to accelerate at a pace too rapid for markets and society. As the scale of business activity grew so immense in the late nineteenth and early twentieth centuries, an informal network of supply chain relationships was insufficient to keep up; *structural scaffolding* would be required in place in order to codify this potential massive economic growth. Big organizations in the form of government and private corporations instituted *frictions* into the business markets; Henry Ford and his contemporaries implemented vertically integrated supply chain systems that enabled growth, and structured work through the use of Scientific Management to improve the efficiency of the workforce as well. In contrast to 150 years of economic theory fathered by Adam Smith, it was the placement of frictions back into economic activity that prevented the accelerating technology from taking society off the rails, so to speak.

For decades, these frictions served us well; "friction = jobs" in the form of corporations, governments, and non-governmental organizations (NGOs), enabled a *multiplier effect* of high paying jobs translating into higher consumer demand. Today, as technology grows in its role in business, displacing labor, these very same frictions are being eliminated from markets while an outdated twentieth century supply chain system stays intact; disintermediation reduces jobs through the automation of job functions in manufacturing, services and the public sector but there are few corresponding changes to the structure between labor, capital, and technology. As consumers, we view disintermediation as a good thing because technology can "cut out the middleman", or lower the cost of manufactured goods, providing us the lowest prices in a seamless manner. Yet in the workforce, it is often us who are displaced by the robots and automation, leading to a *divider effect*, degrading our economy because we are not connecting the dots. To some, like Professor Graeber, these lost jobs (or *friction* roles) in a production line, call center, or government office is "meaningless, dehumanizing bullshit jobs"; but to others, these positions offered a decent middle class lifestyle for the worker and his family. Therefore, the movement toward more automation through technology leads to the *friction paradox*: the elimination of the transaction cost (friction) that is liberation to the consumer while at the same time being a devastating *divider effect* to the worker.

In the twentieth century, there was one lubricant and one friction critical to economic growth being the two *Big Os*: Oil (the lubricant), and Organization (the friction). Without both of them, the massive transformation growth of technology in the twentieth century would not have been achieved. Prior to the late nineteenth century, work effort was limited to the human or animal muscle power. However, through the use of cheap and abundant fossil fuels, that was about to change. Oil economist Nate Hagens calculated that a barrel of oil has 5.7 million BTUs, or 1700 thousand watt hours of energy. In comparison, a human can produce 0.6 thousand watt hours a day; in comparison, it would take a human 2833 days, or 11 working years to equal an equivalent degree of energy as a barrel of oil (Hagens 2013). From a financial standpoint assuming a $100 barrel of oil and the average U.S. labor rate, it would take $500,000 of labor to equal the $100 cost of one barrel of oil (Hagens 2013), and even $1 million at today's oil price of $50 a barrel! In a factor of 5×10^3 or higher, the use of fossil fuel became an energy revolution that led to remarkable transportation and mechanization, leading to our modern industrial economy. A staggering 90 % of economic growth over the past 40 years has been related to energy and 85 % in the past 12 (Hagens 2013).

As powerful as oil is to enable work, it wasn't sufficient; when markets and supply chains were ready to be unleashed through cheap and abundant work through energy, there was no organizational scaffolding in place to transform the growth; economic historian Joel Mokyr of Northwestern University noted that these machines, techniques and supply chains all required careful tending (The Economist 2014b) that was the friction put into place through organizations. On the backs of scientific discoveries would be required of socio-organizational ones; business system and governmental structures that were unnecessary before. In the nineteenth century, businesses were run through smaller, owner operated processes, with less rigid relationships within a supply chain. Growth was achieved through friction, namely the frictions that were put into place through the structures that allowed small businesses to grow big into large corporations, supply chains, and eventually multinational corporations amidst massive global supply chain systems. Today, it's these very same frictions that enabled economic growth in the twentieth century that are being disintermediated through technological change while the structures remain!

Frictionless Markets…Terrifying Concept?

To summarize: through an acceleration of technology and the proliferation of the Internet as a middleman to disintermediate, market activities must transition from a condition of higher transaction costs, linear supply chains with formalized supplier relationships and conditioned workers in large organizations, to zero or minor transaction costs in a completely unstructured supply chain relationships that emerge spontaneously, including the blurring of the lines between a consumer and producer (thus becoming the *prosumer*). The concept of a new market model that is dependent upon technology to be enabling rather than disabling to labor is a terrifying concept for many, given how technology has displaced labor over the past decades, but this is the only solution to fix the problem! Radical change through a deeper government social safety net cannot be the solution, and neither can the overthrow of capitalism through populist campaigns, such as the *Occupy Wall Street* movement. Truthfully, it is the use of *frictionless markets* via a peer to peer economic system that will be the solution to the problem of accelerating technology, as ironic as it may be to consider.

Twenty years ago when I was looking for a job as a young graduate, I remember hearing Bill Gates, then the CEO of Microsoft, speak of an “information superhighway (that) will extend the electronic marketplace and make it the ultimate go-between, the universal middleman. This will carry us into a new world of low-friction, low-overhead capitalism, in which market information will be plentiful and transaction costs low” (Gates et al. 1995). As I think about the changes that I have seen over these past two decades in my career, I realize that back then, I could never have imagined what I am seeing today, and this will only accelerate into the future via Moore’s Law. If technology continues to drive change, and this pace continues to accelerate, it seems to me that the best approach is to embrace new supply chain structures and economic markets to optimize, rather than reverting back to the past.

I will keep this in mind as I tell the story of how the concept of *frictionless markets* will exist by 2030, the dateline that I have chosen to present the case studies of different business models. Step by step, I will describe how each piece of the business puzzle will change from this twentieth century system to the new model for our present century. Tied to the trajectory of the technology will be the system in place to go along with it; how we as consumers, workers, producers and citizens must adapt. It isn’t so radical of an idea to assume that in our future, we will act more as free agents than lifetime members of a large organization; we will neither be identified as workers or owners as is delineated today. All of us will be able to produce and consume on an equal basis as anyone else. Through empowering technology, frictionless markets will break down the barriers of entry and opportunity, with innovation, not capital leading the way to future endeavors. Today, you may consider this to be a scary proposition for your future, or too grandiose since it proposes to untether us from both the security and insecurity of large organizations, but I consider it to be the ultimate expression of what capitalism is intended to be; at least when it and accelerating technology were both mature enough to lead to optimal outcomes.

What This Book Is About

This book is not a science fiction, a conceptual notion of what the future can be, but rather a realistic outline of the future of technology, systems, and markets. To build this storyline, the first chapter will commence with an understanding of *An End to Growth*, an era of comfort for most of us. No doubt, it was the greatest century of economic growth in the history of man, and as a result, many of us nostalgically dream of a return to these days: the USA starting in the 1950s when society grew leaps and bounds through a post-World War II consumer economy, good manufacturing jobs, and a relatively prosperous society. If any phrase should be used to describe what happened during this era, it's that Americans were *supersized*; cars and houses became large, and we were outfitted with appliances and gadgets of all sorts in order to improve our standard of living. Driving this way of life was Big Oil, Big Business, Big Labor, Big Technology and Innovation, and unfortunately, Big Environmental Damage. Today, this *bigness* that Americans experienced in the 1950s up to the 1970s is no longer possible in a world that desires a similar standard of living leading to economic growth. Over the past 40 years, the air from our balloon has deflated, and now we are on the cusp of a new era that scares us because it doesn't offer us the security that we felt in this earlier era.

In Chap. 2, the concept of design will be discussed; what exactly do we mean by the word, *design*, and how is its meaning in science and life different from that of business? The discipline of Material Science was a critical one in the twentieth century, and material designers became Gods, so to speak, by designing synthetic materials that were foreign to nature, which led to both good and bad repercussions. Will Man be able to mirror Nature in his understanding of design, or will he be replaced by the supercomputer in a frictionless model? This topic will be addressed in Chap. 2.

Whenever there is a conversation in regard to the future, the tenuous state of our natural resources is always a topic. In Chap. 3, the future of materials will be addressed, both in the use of natural resources, and synthetic materials from natural resources. In our Industrial Era, natural resource materials have been used as if there is no limit, which was acceptable in 1900 when the world was under 1.7 billion, but not today when the population is over four times higher at 7.3 billion, at a higher standard of living. No longer can Man only consider the extent of how materials are consumed, but rather, as a starting point in how they are designed. And what is the goal of a material in use—to be consumed without regard, to mitigate damage, or to actually design a material that actually does good after use? In this chapter, I turn our present definitions of materials and their use on its head to develop a rational approach to consumption and production in the twenty-first century.

The future of manufacturing is the topic in Chap. 4. Manufacturing has been critical to the development of the United States since its inception, and while there are some who believe that its importance as past its time in the U.S., the truth is very different, but of a twenty-first century approach. Changes to our definition of manufacturing will change everything that you have ever known about the discipline; it will no longer be dominated by behemoth, capital intensive factories of subtractive waste, first in the U.S., then in China, but something radically different. In the future, you will be able to be a producer, and what will and can be produced will extend beyond what you can imagine today.

Chapter 5 is a vision of the future supply chain, but one very different from what you can imagine today; it will no longer be this discrete, orderly, linear cluster of large organizations, often global in nature, but a complex web of emergent *prosumers* who organize spontaneously in peer to peer relationships. With few or no frictions in place due to technology, the structure of the future will radically change business and society, and the conventional linear structured supply chain will disappear.

To provide a visualization of this future *frictionless market* model, I will provide five examples of frictionless markets of the future year 2030. In these examples, I will show how they are designed, and how *prosumers* will work within fulfillment centers, and the involvement of governments in this new approach. Finally in the conclusion chapter, I will not only address why this is possible, but also why it is critical to move in this path. After all, a peer to peer approach to capitalism is the best approach to take advantage of accelerating technology that offers great hope for the future! Let us begin this journey!

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Chapter 2
An End to (Twentieth Century) Growth?

Germs and Bugs

Today, there are various theories regarding how long humans have existed on earth, with anywhere between 100,000 and 200,000 years as a legitimate estimate. If we play it safe and use 100,000 years, Fig. 2.1 below represents the economic activity for only 2 % of our existence as specie, with the first 98 % registering either nomadic activity, or sustenance farming of little consequence. In this narrow band of the 2 % of human activity, shown in Fig. 2.2, approximately 90 % of this short period shows little economic activity as well; it has been the last 200 years, or 0.2 % of human existence, where we can actually measure technological progress to the extent we consider today. Therefore, for almost all of human existence, life has been in a "state of nature", outside of an industrial economy, best described by seventeenth century philosopher Thomas Hobbes as "solitary, poor, nasty, brutish, and short." Without question, there have been great inventions through the last millennium, but to use a term from Ted Kaczynski noted in the last chapter, it was "small scale technology" of a limited application. Prior to the Industrial Revolution, most of humankind's population was focused on matters of sustenance; in 1500, an estimated 75 % of the British workforce toiled in agriculture, and that number declined to 35 % in 1800 (The Economist 2014), and well under 10 % today. As technology got larger, moving from small scale to large scale, the machines took over in the fields, pushing the workforce into the cities to work in the factories, and then again, pushing the workers from the factories into the white collar jobs. Today, as we have discussed in this book, automation continues to displace labor through capital; the big question of this book is what to do about this paradoxical problem.

The history of the United States is a story of a *labor problem*, of changing challenges. In the year 1607 in the first permanent settlement in Jamestown, Virginia, the settlers had a *labor problem*; first, in surviving the Indians, and then the germs of the New World. This first permanent settlement landed unluckily in the middle of the powerful Powhattan Indian tribe, leading to a threat of survival. History books have sometimes led us to believe that the Europeans conquered the New World due

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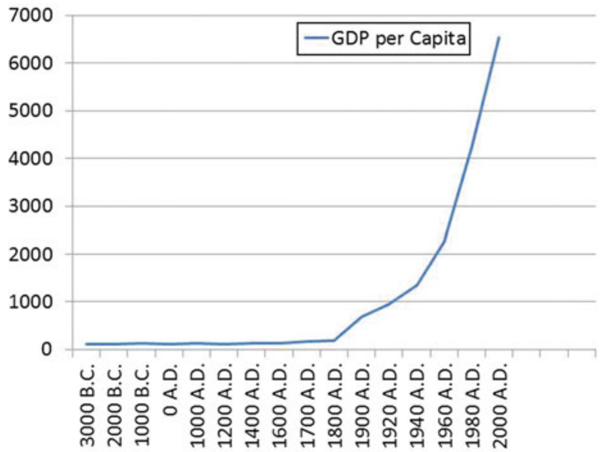

Fig. 2.1 History of economic growth (*Source*: De Long 1988)

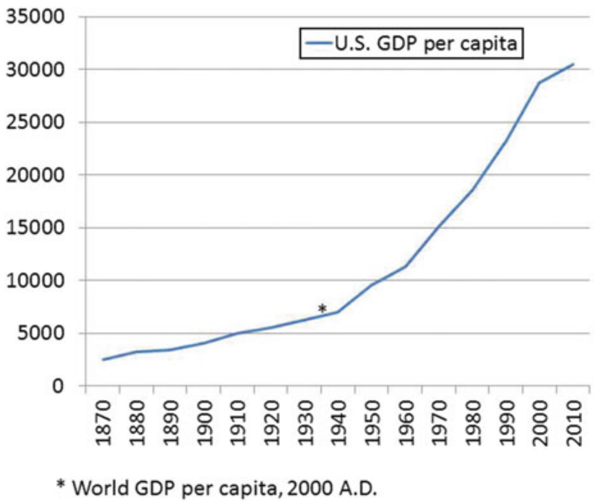

Fig. 2.2 U.S. GDP per capita (*Source*: Angus Maddison)

to superior technology, but this is an unproven assertion; settlement leader John Smith said himself about the gun, “an awful truth that it could not shoot as far as an arrow could fly” (Chaplin 2001). Perhaps the best weapon the settlers had against the Indians weren’t their guns, but rather what existed in their bodies: *germ warfare*. After thousands of years of farming in Europe under close quarters with animals, the Europeans developed immunity to diseases such as measles, smallpox, and influenza that had a devastating effect on the Indian tribes (Diamond 1998). As Jared Diamond noted in his widely acclaimed book, *Guns*, *Germs*, *and Steel*, “it’s striking that

Native Americans evolved no devastating epidemic diseases to give to Europeans in return for the many devastating epidemic diseases that Indians received from the Old World" (Diamond 1998). With 95 % of the Indian population eradicated due to imported European germs, the settlers were able to invade, but not conquer the land.

Conquering the Indians was one thing, but the New World itself was yet another; a "surplus population" of Englishmen were sent over as indentured servants to do the work, making it a "dumping ground" (Waldstreicher 2004), but almost half of them died before their term of service was complete (Kolchin 2003). Without an adequate workforce, the vast resources of the New World would never have been cultivated, impacting the history of America. In 1619, a solution, however immoral, was to save the day: the use of African slaves for field work. The Colonists soon learned that the slaves from Africa were not susceptible to illnesses, such as yellow fever and malaria that had such a great toll on themselves (Mann 2005). Beyond a moral dilemma, African slaves were bad economics as well; the use of chained, unwilling, uncultured laborers appeared to be inefficient to a surplus of Europeans. However, we know today that it was biology that trumped morals and even economics to solve this *labor problem* to conquer the New World; this scar that remains on our history was a labor solution of germs, not economics, per se.

For hundreds of years, it was the immoral use of slavery that solved America's *labor problem*, not rectified until its abolition with the ending of the U.S. Civil War. Yet an end to this moral depravity came at a heavy price to the economy of the South. According to a study conducted in 2011, the value of slaves in the South in 1860 was $10.2 trillion, nearly half of its overall wealth; it was hypothecated that there was so much invested in slavery that it "crowded out" other forms of investment (Williamson and Cane 2011). This Reconstruction Era threw the South into turmoil; ex black slaves wanted their promised "40 acres and a mule", while white property owners protested over a 50 % loss of their wealth. At the same time, the industrial North was taking economically through its new found use of the *superlubricant* of fossil fuels, namely coal. Slaves may have been a cost effective, yet immoral solution to this *labor problem*, but nowhere close to as economical and effective source of work capacity as fossil fuels. First it was through transportation, and a railroad system was put in place; in 1869, a *golden spike* was nailed down in Promontory Point Summit, Utah, and the word "done" was telegraphed across the U.S., the transcontinental railroad was in place, and economic healing was on the way. As a response to this telegraph, the country hypothetically should have responded back: "now supersize us."

Oil: The Superlubricant

The pieces were in place for bigness, greatness; the abolition of slavery, a transcontinental railroad for a continental country, the platform of a robust manufacturing economy, an immigration policy to support labor and a beginnings of a nationwide supply chain system in place. It was the underpinnings of fossil fuels that would prove to be the super-lubricant for economic growth. Coal was being used for railroad steam engines, and kerosene used for illumination, replacing whale oil. In these early years of kerosene as the use for oil, there was a dearth of structure to drive change in the industry; with thousands of manufacturers and distributors, prices and waste was high, leading to a lack of scale. It was not until the Big O of Standard Oil, led by John D. Rockefeller where modern day practices of a corporation were put into practice. A by-product of the kerosene production process was a noxious material called gasoline that many refiners couldn't wait to get rid of; they threw away barrels of the stuff in creeks and rivers, even dumping it into the ground, leading to numerous deaths. Rockefeller, on the other hand, found a use for this material as a fuel for his kerosene refining process. As we know today, Rockefeller and Standard Oil would enable the large scale production and distribution of gasoline that would later power the automobile age, leading to a transition in the oil industry that was necessary, as the innovation of electricity ended the use of kerosene for illumination. Legend has it when Henry Ford rolled out his first automobile, a Standard Oil salesman was standing next to him, with a can of its trusted fuel. Big Oil, alongside Big Organization, were about to propel the U.S. economy.

Through his use of organization, John D. Rockefeller was an example of American ingenuity; how to take a waste material and form it into use for greater economic growth. Not just in science and technology improvements, but management techniques as well, not withstanding his use of monopolistic business practices. As a result of leaders such as Rockefeller, the U.S. dominated world oil production for the first half of the twentieth century; the U.S. accounted for 70 % of world oil production in 1925, 63 % in 1941, and 50 % in 1950 (Encyclopedia of the New American Nation 2014). Yet before oil production and consumption in the U.S. could lead to meaningful economic growth, it would need to lead the Allies in victory in World War II; the U.S. accounted for six billion of the seven billion barrels of oil consumed by the Allies (Encyclopedia of the New American Nation 2014) in its winning effort.

After World War II, America returned from the battlefields with yet another *labor problem*; the return of GIs from war into a peacetime era without the appropriate skills to usher in a new economy. With a glut of excess manufacturing capacity at the U.S.'s disposal that was no longer needed for producing tanks and guns, new policy strategies were undertaken: one, to create the GI Bill to enable servicemen to go to college and buy homes, and the inducement of a peacetime economy built upon spending not saving, redeploying available capacity to pent-up consumer demand. A new consumption based economy was ready to be unleashed on the back of pent up demand after years of sacrifice, technological advancement, and a supply chain structure in place, powered by cheap and plentiful oil. As is shown in Fig. 2.2, the perfect cocktail of ingredients existed for GDP to rise dramatically, starting in the 1950s: a demand driven economy, fueled by abundant cheap oil, with a sufficient balance between technology and labor to enable the multiplier back to demand.

Big Oil served the U.S. economy well in the 1950s and 1960s, leading to dramatic growth, but it could not last forever. Between 1950 and 1972, total world energy consumption has increased 179 %, a doubling of per capita consumption during this period; during this era, other nations in Europe and Asia started to arrive to the party. Unlike any other era in human history, the growth in energy production and use was far beyond a necessity to keep us warm and well fed. Oil economist Nate Kagens noted that the average American consumes 230,000 kcal of energy in a day, with only 2500–3000 endosmotically; the remaining 99 % is consumed outside of our bodies, primarily in use in transportation (Rapier 2014). A mechanized world was upon us, extending Man beyond the natural world; life would no longer be required to be "nasty, brutish, and short". This infinite source of energy would also come with a price; according to consensus in the scientific community, human civilization cannot survive a worldwide temperature increase of 2.0 °C, of which we've already consumed 0.8° of that allotment. In order for stay under a 2.0 °C increase through the middle of the twenty-first century, the Carbon Tracker Institute has calculated that humans can emit only 565°Gt of carbon emissions despite known fossil fuel reserves of 2975°Gt, over five times the amount we can safely burn (Hayes 2014)!

How will this clash between industry and nature end: can we continue to rely upon the *superlubricant* of Big Oil for growth, and if so, at what price to our environment? Perhaps of more concern, can we expect the energy companies and oil producing nations to keep $20 trillion in wealth in the ground, roughly double the wealth (in today's dollars) that staggered the South at the end of the Civil War? The *end state* of our dependence on the Big O of Oil to drive economic growth is an existential question that will play itself out over the course of our lifetimes!

The Elementary Particle of Business

Prior to the Civil War, there were no large organizations to speak of, either public or private. The U.S. was almost entirely decentralized prior to the Civil War; there was no national banking, no sufficient transportation system, no national tax system to pay for a larger government. In 1900, 55 % of public spending was local government while today, 68 % is federal based. The Civil War was the beginning of the movement toward a large scale socio-organizational approach to the U.S. versus a boundary of fairly independent states, and micro-organizations. Railroads would begin to change this through the development of professional managers who specialized in railroad administration, developing standards of performance, and sharing new ideas (Brands 2010). Not only was the railroad the single largest employer in the U.S., it helped to structurally organize the nation, including the implementation of *time zones* from the earlier concept of *solar time* in order to standardize train schedules.

At the onset of the twentieth century, organizational structure, and one of its first methods, *scientific management*, found its way into the lexicon of American business. In 1911, Frederick Winslow Taylor published the book, *The Principles of Scientific Management* that sought to address, in Taylor's own words, "the great loss which the whole country is suffering through inefficiency in almost all of our daily acts" (Taylor 1967). To the newly formed role of management, these exercises were seen as a reduction of waste, or *soldiering*, as Taylor called it, formalizing tasks within a production setting in order to allow for unskilled workers to perform a specialized task. To others, this *deskilling* of work was taking the job from an artisan, and *dehumanizing* work in order to lower wages and threaten workers. Regardless of the perception of this organizational approach to work, it did lead to dramatic results in the early twentieth century; in 1910, it took the Ford Motor Company 12 h to build a Model T, and in 1914, it took 1.5 h. Ford cut the cost of an auto from $950 in 1909 to $295 in 1923, and he sold 1.3 million vehicles in 1921 versus 79,000 in 1912. This new *structuring of work* was tied to economic improvements; the *Big O* of organization was the friction that enabled the *Big O* of oil to be the lubricant, leading to transformational outcomes!

What Frederick Taylor did for the *Big O* of organization on the shop floor, British economist Ronald Coase did for the large organizational structure side. Coase posed the question, "if most economic decisions are organized by the market, why do firms exist; production can be handled without organization, so should firms rationally emerge?" This was a timely question to be asked at the onset of the twentieth century when the industrial economy began to ascend; after all, there appeared to be a diminishing return from the liberation of markets from Adam Smith's *invisible hand*. In 1937 when Coase wrote his famous work, *The Nature of the Firm*, there were "islands of central planning in a sea of market negotiation"; a lack of structure prevented scale being created in order to prevent an inordinate amount of time of organizing versus having prebuilt scaffolding already in place. The economic friction, according to Coase, was the "transaction cost"; Coase acknowledged that frictions already exist in business, and therefore, the preordained creation of friction in the approach of a transaction cost would increase the efficiency in a newly created concept: the supply chain structure.

Organizations and supply chains would be able to codify through this concept of the transaction cost; cooperation would achieve what pure competition could not. Thirteen years later, mathematician John Nash published his dissertation on "non-cooperative games", suggesting that it is more fruitful for organizations to work together rather than to compete. In the 1930s, Alfred P. Sloan's General Motors Corporation was run in this fashion of a highly organized corporate structure with checks and balances, central planning, and formalized supply chain structure with its suppliers. A corporation's path to success was enabled through its approach to organization, both within its walls and with its suppliers; up until the twenty-first century, the Coors Brewing Company (a company where I have worked) had successfully achieved market growth through a vertically integrated supply chain system, where it controlled a large percentage of overall operations. As late as the 1990s and 2000s, companies such as Dell Computer and Wal-Mart achieved market dominance through structural relationships with suppliers through the friction of transaction costs. Don't get me wrong, competition remained important in the marketplace, but it was organizational structure and cooperation that led to bigness, to growth. But this would come to an end as well; with increasing technology, these frictions would find themselves in the way of future growth, as will be discussed in this book.

Twentieth Century Lottery Tickets, Labor and Standards of Living

Not just *the Big Os* of Oil and Organization, the twentieth century was also about the implementation of big ideas that were not possible before, and can never be reproduced. In the twentieth century, there has been more material progress made in the U.S. than in the entire world in all of the previous centuries combined (Bailey 2012). The list of accomplishments in the twentieth century is overwhelming—life expectancy increasing by 30 years, infant mortality falling tenfold, air quality improvements by 30 %, agricultural productivity increasing five- to tenfold, GDP per capita increasing from $4800 to $31,500, and real wages from $3.45 to $12.50 (Bailey 2012). Think of all of the great inventions in the twentieth century—electricity, the automobile, airplane, electronics, agricultural mechanization, the telephone and television, air conditioning, highways, spacecraft, imaging, petrochemicals, nuclear power, and so on! This is the good news; but as noted historian Niall Ferguson has stated, the bad news is the scale of these innovations lends itself to happening only once. Is this explosive, transformational growth within a tiny 0.2 % of human existence an anomaly, never to happen again, or something that can be continued into the future? Perhaps the U.S. and others in the developed world were the beneficiaries of a one-time lottery ticket in the twentieth century, never to happen again!

The twentieth century may be the only century in America's existence where there was no *labor problem*, per se. In the century beforehand, the Industrial Revolution was in full mode, and the movement of low skilled immigrants, women and children was creating massive conflict; between 1881 and 1905, there were 37,000 strikes, impacting 7 million workers in a nation of approximately 76 million. As manufacturing moved toward a *deskilled* model with the *system first*, increasing numbers of immigrants, women and children entered the workforce, leading to a tumultuous arrangement. In this frictionless market arrangement, only 45 % of American workers earned yearly wages above the poverty line of $500 (Corey 1934). An organizational friction that was put into place to diffuse this powder keg was the labor union; as is shown in Fig. 2.3; union activity in the United States began to rise as a function of these disturbances. This *friction organization*, as I call it, led to higher wages and prosperity for the U.S. worker until their declines that began in the 1960s and 1970s.

Through the lubricant of Big Oil, and these frictions of Big Organization, innovations proliferated leading to the *one-time lottery ticket*, and a consumer based economy built upon the unleashing of consumer demand. The post-World War II economy until the early 1970s led to a swelling of the middle class, and a circular Keynesian economy built upon higher wages leading to higher buying power leading to an enablement of innovation, which drove higher production. In between the cracks were these Big Organizations, who were effectively the *wizard behind the curtain*; Big Government driving enabling policies (GI Bill, Highway Program, Tennessee Valley Authority, Social Security Administration, and etcetera), Big Labor driving

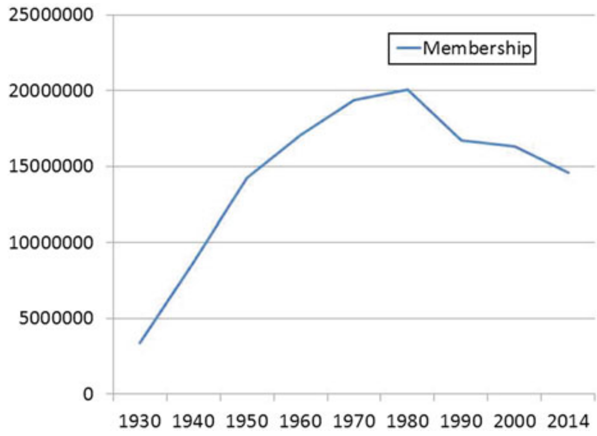

Fig. 2.3 Union involvement in the U.S., twentieth century (Cornel.edu/federal publication)

higher wages, and Big Business and their behemoth organizations, and *jobs for life*. The *baby boom* led to a demand surge in single family homes, automobiles, household appliances, and a change in ideology from frugality to waste. On August 1, 1955, a declaration of independence from drudgery was presented to America in *Life Magazine* in an article titled, "The Throwaway Living." In this new *throwaway society*, housewives and their families could achieve liberation of the day to day through one time use meals and packaging, and a *planned obsolescence* of bigger ticket items, such as cars and appliances that further prompted a consumer based economy. Of course, none of this was built to last.

The Party's Over…the End of *Big Os*

These frictions that were put in place in order to *scaffold the growth* of the twentieth century are now outdated. In comparison to 1900, Americans are working less (40 versus 60 h) and spending less of their incomes on food (15 % versus 44 %), and producing/consuming six times more (Bailey 2012), yet as was shown in the Introduction chapter, economic productivity is far outpacing a growth in labor wages, which signals a problem with this twentieth century *frictioned economy*. Aside from those who espouse conspiracy theories and class warfare rhetoric, the rationale is abundantly obvious: the hardest hit is the lower classes, and a growing impact on the middle class. As technology moves its way up the food chain of jobs, it grows in its impact on higher, more skilled roles and moves onward; as it stabilizes its impact, it pushes down on wages since wages now have to compete with lower capital entry for automation, and more workers seeking fewer real jobs.

In a 2011 report, McKinsey & Company noted an increasingly longer period of jobless recoveries sweeping over the economy. As the impact of automation technology grows in significance, middle class wages in the U.S. have stagnated; before, it was only manufacturing facilities that saw job loss to automation, and even global outsourcing, but now it is impacting the white collar jobs of the services industry that is happening. U.S. median household income has fallen, from $53,252 in 1999 to $52,823 in 2007 (in 2010 dollars) while at the same time, incomes for the very top of the population are growing. The case I am making is this: quite simply, these data represent not intentional economic programs that favor the upper class over the lower or middle classes, as is sometimes portrayed in the popular media, but rather an unintentional disconnect of an outdated economic system that favors capital over labor. As technology accelerates in an exponential manner of improvement, this will increasingly worsen this condition, which means we must change our economic structure.

Is the party over, an end to economic growth? In his 2012 essay "Is Economic Growth Over?", Northwestern Economist Robert Gordon noted that all of the obvious innovations have been achieved (the one-time lottery ticket), and the impact of innovation in the future is overrated, while the threats posed by structural problems, such as education declines, have been understated. Gordon, who is called, "the most depressing economist", contends that "techno-optimists" are overestimating its potential positive impact on the future (Goldfarb 2014). Similar to Gordon, Tyler Cowen's *The Great Stagnation* (2011) also finds a technological impasse, rather than acceleration. Richard Heinberg's 2011 *The End of Growth* takes on a more Malthusian view, finding that our use of natural resources cannot continue, and the only rational mindset is to promote a system that does not require growth as a foundation. And of course, in 1972 The Club of Rome published its book, *The Limits of Growth* that was revised in 2004 *Limits to Growth*: *The 30 Year Update*. As economists and environmentalists do, these works are built upon an obvious foundation that (a) we cannot continue to use natural resources as we do (b) the big innovations have already been found and (c) if we project our current trajectories out into the future, growth is no longer possible. I believe that if we are forced to predict the future from this lens, this is true, but the question should be why must we remain within these old paradigms of thinking? In his book, *The Black Swan*, Nassem Talib finds that economists are rarely successful in their predictions because the future rarely mirrors the past, which is used to create their models.

In the remainder of this book, I will propose a new paradigm for the future using a new frictionless economic model must be implemented to design products and use resources different than we have done from the past and manufacturing and supply chain systems must be transformed to build frictionless transactions, including our role as workers, consumers, producers and citizens. If these changes are undertaken, not only will growth continue, but it will thrive. As is in nature, when something doesn't work, organisms emerge, not fall back.

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Chapter 3
Nature's Approach to Design

God, Nature, and Supercomputers

Should products be designed as has life has been? If there is something for us to learn as product designers, the question is: is life on Earth due to a *design and designer*, or is it a result of a mechanical, slow, sequential process of emergence? In this chapter, I will delve into science to determine whether there is something for us as product designers to learn from nature about how our products should be conceived in this new twenty-first century frictionless market, and it is much different from how we do things today. From this learning will be the beginning of how we transform our supply chains and markets in this new model, one without the frictions of large organizations.

Has life on Earth been designed? A pro-design view of life is illustrated through Peter Ward's 2000 book, "Rare Earth: Why Complex Life is Uncommon in the Universe." According to Ward's *Rare Earth Hypothesis*, life had to occur through some type of intelligent design; for life to exist on a planet, it must be in the right place in the right type of galaxy, orbiting the right distance from the right star, amongst the right other grouping of planets, all having proper orbits, and be a planet of the right size, with the right orbit, plate tectonics, a large moon, an evolution procedure, and fortune in this process (Ward and Brownlee 2000). But wait, there's more: a 300 molecule-long protein must be formed by total random chance, which is odds of approximately one chance in 10^{390} (Ward and Brownlee 2000). This level of improbability becomes even smaller when trying to explain a model of a more complex bacterium rather than a simple protein! Ward's conclusion, and that of others who support an Intelligent Design point of view, is only through a designer are these types of odds possible. What can product designers learn from this system? Not much, as the omnipotence of a *divine designer* is well beyond our capacity, and there is little hope in bridging the gap; we will never become Gods.

The alternative to an intelligent design approach is one without design, per se, and the result of a sequence of glacially slow, meticulous, and essentially mathematical steps. In this model, we start with the hypothesis that there are three trillion stars in

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the Milky Way and therefore, a probability that there are 40 billion Earth sized planets and from this, 11 billion that orbit sun-like stars (Petigura et al. 2013). Theoretical physicists point to a star named *Gliese 581* that was found 20 light years away from Earth with a planetary system of at least three planets. Within this system, at least one of the planets, Gliese 581-c, appears to possess the potential for water, an atmosphere, and a temperature range that could support life. In his 2009 book, "The Crowded Universe", research scientist Alan Boss counters the *Rare Earth Hypothesis* by hypothecating that not only is there "another Earth" out there, there are lots of them, and with so many habitable worlds, it's likely that something would be growing on them (Boss 2009). From this point of view, there is a recipe for life that is from an emergent, abiogenesis process of slow, self-replication governed by chemistry, natural selection and mathematics. If the problem in replicating intelligent design as product designers is our lack of omnipotent knowledge, the problem with emergence is time: the amount of time that it would take to lead to *perfect design* through self-organizing and natural selection; product designers have maybe a few years in today's model, but definitely not hundreds of millions of them!

What can the future of design take away from emergence to support the concept of a frictionless market model? This will be discussed in the remainder of this chapter in comparison to the past and present of industrial product design. In the nineteenth and twentieth century product design model, a human led *Edisonian* model of trial and error occurs as is follows: an inventor builds a physical representation of a product, using *a priori* knowledge, and then tinkers with it until he runs out of money, patience, or it works to some extent. This model can no longer work in our supply chains of the future, given the temporal expectations of a business model built on a function of accelerating technology. Can a product design model that mirrors nature's approach to emergence and self-organizing in a complex environment solve our current state challenges? To answer this question, I will dive deeper in the discipline of science to see what can be learned.

Nature Beyond the Metaphor

The beauty and seeming perfection of nature leads some to have a religious, spiritual experience from its design, while others marvel at the science of emergence and self-organization through its chemistry, biology, and physics. However, there is a third perspective of what's happening: a mathematician will watch the rolling of the waves onto a beach, and stand in awe of the sheer computation required for it to occur. Each of us watches the same event with a different experience, interpreting how it came about (how it was designed) in order to describe what is happening. A subject of *design* provides unique perspectives regarding one's view, understanding, discovering, and replication of the natural world. Today, there is an opportunity for industry to look to nature, not to replicate it, but rather to gain an understanding in order to build our products of the future; nature is no longer just a warehouse of unlimited resources, but rather, a cache of ideas for the future. While this is an exciting opportunity for business and markets, it first requires a paradigm shift in our thinking in order to get there; we cannot *design products as nature* within our existing supply chain structure and timeframes. Does this mean that our use of design from nature will simply only be a metaphor?

As a starting point in this discussion is Janine Benyus' 2002 book, "Biomimicry: Innovation Designed by Nature" that provides significant and topical examples for how species and ecosystems are designed usefully to be *fit to purpose* within its ecosystems. In industry, products are designed to fit a consumer purpose without a holistic existence within a broader setting: a plastic water bottle is designed to be efficient (lightweight and cheap) for distribution and consumption by the consumer, but not holistically, as is evident through hundreds of millions of landfilled and littered bottles in a single day. In nature, there are clear examples of how utilities are built into a material or life form that could be replicated for benefit in industry, such as nature's superior ability to be powered only through renewable elements, such as sunlight, wind and water, as well as nature as a cyclical, renewable system without the need for landfills. Benyus' book is full of examples of how nature has produced superior design to *fit for purpose* without a manufacturing model of "heat, beat, and treat" that wastefully exists in our present day industrial model (Benyus 2002). We can appreciate that nature should no longer be considered a resource that is to solely be mined rather than a mentor from which we can learn (NYSERDA 2009); but the challenge is a greater understanding beyond a metaphor in order to build into how products are designed, sourced, manufactured, distributed, used, and disposed.

How can these beautiful elements of nature, as described by Benyus and other biomimicry proponents, be considered in a frictionless market model of the future in order to make a meaningful difference, and not just be a *nature metaphor*? As someone who conducts research in biotechnology while also having footing in industry within a consumer products industry, I believe there is a wide gap between today's industrial model and one of a future that could be biomimicry-inspired. Scientists focus on the design or emergence of a spider's silk in nature in regard to strength and flexibility of material science requirements, but not how this type of material would be designed, sourced, manufactured, distributed, used and reused in a modern day supply chain system. In other words, there is a viewpoint from science that once we are able to physically replicate the nature of a spider's silk from a material science standpoint, that we will have solved the problem. This thinking is not only a misgiving from an overall supply chain standpoint, but related to that of nature as well: self-emergence and self-organization is more of a process than a solution, and design and material innovations will not occur without process (supply chain transformations) first and foremost.

Today, in the industrial world, our design processes are constrained by this human centric *Edisonian* model of limited (human) computation; in the future, I am advocating a virtually infinite computational model of design that is a *no design* approach, like exists in nature through emergence that will only be possible when supercomputers are able to do so. As such, the long tedious process of the *Edisonian approach* will be replaced, and nor shall we expect to follow a glacially slow process that exists in nature of natural selection, self-organizing emergence. Through this sheer computational power will be the *no design* paradigm of our products in a twenty-first century frictionless market.

The Software of Life

Evolution (and therefore, biology) behaves very much like a computational process (Zenil and Marshall 2013); in fact, it has been said that "DNA is essentially a programming language that computes the organism and its functioning: hence the relevance of the theory of computation in biology" (Chaitin 2011). Therefore, important aspects of computation help us to understand biology, so it would stand to reason that understanding technology in life can help us in our industrial world as well. Noted biologist Richard Dawkins stated that, "it is raining instructions out there; it's raining programs; it's raining tree-growing, fluff-spreading, algorithms. That is not a metaphor, it is the plain truth. It couldn't be any plainer if it were raining floppy disks" (Dawkins 1989). To Dawkins, it isn't life forms that compete for self-replication, but bits of code itself (Dawkins 1989). In this model, there are no instructions, no design, rather just self-assembly in a natural coding process.

If the gene is just a bit of code, and it's a replicator that becomes the center of life itself, couldn't it be possible for software code to become the center of all product development through a similar self-replicating process? Yes, but this is only if we believe that this "selfish gene" coding process is all that it takes to create life, which is not a belief widely acknowledged by most geneticists today. In Keller's 2000 book, "The Century of the Gene", a history of genetics is outlined, including how a theory of "The Selfish Gene" was developed to describe this pure computational model of self-replication and natural selection (Keller 2000). Most geneticists believe this model of "genetic determinism" has been disproven to describe evolution, given the role of other factors involved, such as the chemical nature of genes and environmental factors (Newitz 2013). As in life in product design, sheer, powerful computation is important, but not enough; there is *something else*, whether it is elements in the environment, or something invisible that we do not yet understand. In product design, this can be considered the *human element*.

Man's Limitations in Product Design

Perhaps in the development of life and products, this concept of *design* incorporates some art, engineering, business planning and execution, and other variables. As is shown in Fig. 3.1, this process in the past has been sterilized into a structured, linear, sequential process appropriately called the "waterfall model", as it cascades downward from one stage to another. While the process is boiled down into simplicity for our understanding, in general, the process follows these steps: first, a designer and/or engineer uses processes of some sort to define and analyze a need, often based upon a concept (idea) developed or even a problem statement. After some planning, a design is developed using a mix of structured processes and/or a *fuzzy front end* of some sort. An *Edisonian* process of *trial and error* is iterated until the design is considered appropriate for prototype, or the process is ended. Finally, even a good

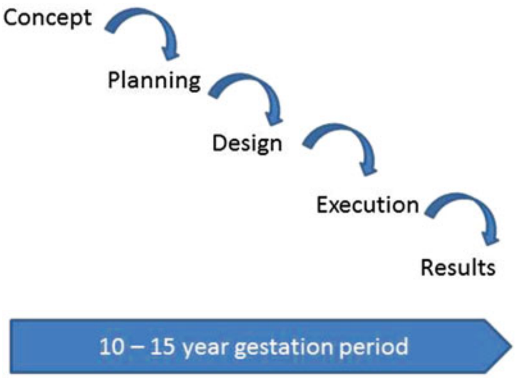

Fig. 3.1 Waterfall method of design, planning and development

design can be rejected once the manufacturing and supply chain elements are considered before going to market.

In this process, there are a myriad of limitations that can impact success or failure, due to the human centric approach; a designer's ability to think beyond linear steps to interactively consider variables, his ability to compute (including a limited use of a computer, such as CAD) an impact of all or even most of the variables, the limits of his creativity, and the time and money limitations of the market itself can crater the process at every stage. Perhaps, most notably, the lack of computational power than exists in a man's mind relative to the time period versus that of a natural process of emergence that can occur over millions of years to calculate is a limitation in defining and solving a design, both functionally and aesthetically. Put simply, Man is a very limited product designer.

In high school, I was taught of these individual geniuses who were born talented in way that virtually all of us are not; in a way, they were considered almost Godlike in their supernatural powers. Thomas Alva Edison, the "Wizard of Menlo Park" was considered this supernatural genius, a man who held over 1000 patents, including the motion picture camera, phonograph, and the light bulb. And yet his most famous quote, "genius is one percent inspiration and ninety nine percent perspiration" (Dyer et al. 1929) emphasizes a different story to us: an inventor must be smart, but most of his success was due to hard work and process more than anything else. Beyond mere trial and error, Edison's model was based upon the knowledge of the day (Wood and Linsey 2007), not a bolt of lightning striking him, leading to supernatural powers. His inventions were not developed from a dream, but rather built upon earlier devices of similar function, and then applying perspiration to finish the job. As Mark Twain noted, "It takes a thousand men to invent a telegraph, or a steam engine, or a phonograph, or a photograph, or a telephone or any other important thing—and the last man gets the credit and we forget the others" (Knapp 2012). Perhaps in this sense, Edison stood on the shoulders of others in his inventions of the light bulb and phonograph, perhaps much like humans being an innovation built from apes and other mammals. If we consider this approach, we may undertake a different approach to the future of product design, taken from nature.

Contrary to our image of Edison and other famous inventors who we believe were touched by God, students in marketing, engineering, and information technology, are taught mundane, linear and sanitary models of product development lifecycles without a shred of creativity that we expect others of past and present (a.k.a., Bill Gates and Steve Jobs) to have achieved. Of course, a real model of product development is more complex and messier than what an engineer or marketing product manager is taught, leading us to ponder the balance required of structured, linear, *stage-gated* processes and *fuzzy front ends*, and complexity. In reality, a waterfall model of design and development is only useful because its interrelations between steps are easier to comprehend, but the boundaries are fuzzy for how it can work (Wood and Linsey 2007) that illustrates the limitations of the human product developer. However, a linear path in the past was necessary, given our inherent human limitations, but all stages would benefit if there was consistent data and communication throughout the process that doesn't exist today (National Science and Technology Council 2011).

An End to (Human Centric) Design

In our twentieth century design model, not only are there limitations from a human's inability to *compute* an optimal product design, there is also the problem of how long the design and development process takes given a lack of data, and consideration of all of the factors needed to be understood for product market success. Product design in large corporations is such a painstakingly long and bureaucratic process that in many cases, the company forgoes anything more than incremental innovation in order to reduce risk and not lose focus on short-term financial objectives. Material development is a long and costly process, and is often constrained to the knowledge that exists within the organization, rather than a larger array of possibilities; MIT Research professor Thomas Eagar has found that it takes an average of 15–20 years for a successful material to proceed from lab testing to a commercial application. This long period of design and development is due to the reliance on scientific intuition and trial and error experimentation, with much of the design and testing of products and materials performed through time consuming and repetitive experiment and characterization loops (National Science and Technology Council 2011). Yet in the end, it is often not enough, and a decision is made without great certainty, often leading to a conservative, risk adverse approach, or greater risk acceptance, and widespread failure.

Examples of prohibitively long product development lifecycles are abundant in literature: the lithium battery took over two decades of costly *trial and error* research (Ceder and Persson 2013), the mouse took almost 30 years to catch on from the first prototype in 1963 (Lee 2013), over 40 years for the internal combustion engine to succeed, with Henry Ford's Model T, and Velcro that took 10 years for the invention, several years thereafter for the patent, and many years later to sell the product to early innovation adopters (Hoffer 2014). Furthermore, with twentieth century supply chain systems of *Big O* focused on scale in energy and organization, there is inertia to reduce cost and drive market share rather than achieve radical innovation in most mainstream markets. As I will discuss in the ensuing chapters, large manufacturers, distribution and retail outlets often seek efficiency and scale, not innovation; but what happens if these supply chain agent's change? In a *peer to peer* supply chain system, scale loses importance to innovation; therefore, innovation cycles need to shorten to breakneck speeds. Instead of a few famous innovators beating the odds in long, slow windows, there will be thousands, if not millions of peer innovators under much shorter time requirements. Therefore, there will be no time for design; products will be conceived without it, and perhaps more appropriately, as a function of its lack of involvement.

Questioning the ability of technology to solve this *problem of design* is like questioning the role of the gene in a self-emergence process: just because there are other factors involved yet to be understood, such as the environment and perhaps some invisible or God-like trait, doesn't mean that sheer computation cannot account for a large portion of the solution. Today, supercomputers are used in a variety of purposes, including the discovery of innovations, but in science, there remains a clear division between the role of a human and computer in the process. Nature obeys the same beautiful mathematical patterns that can be understood by a computer, and vice versa, so is there something to replacing humans with computers in order to replicate how life has evolved? In several fields, such as product design, we appear to be reaching the limits of our intellectual abilities (Manjoo 2011), while at the same time, we are learning of the commonalities that exist in our understanding of computation and what occurs in nature. For example, if a human designer, even with the assistance of a computer, can only factor a handful of the most important parameters into the design of a product while a supercomputer of the future can factor billions in a quick, but powerful computation, will there be any comparison in regard to what is the *best design*? Yale economist William Nordhaus has published in 2007 that computer performance has improved since manual computation by a factor between 1.7 and 76 trillion (Manjoo 2011), and this is only the beginning.

This is not science fiction, but emerging today. Powerful computers are just beginning to calculate the nature of chemical compounds that is leading to key first discoveries not known before about these materials. Once we begin to compute the material properties of our design, we will begin to understand how wasteful our industrial product lifecycle are in the use of *trial and error*, leading to design transformations beyond our current comprehension. The ability to access, search and screen materials and products, from the perspective of almost unlimited degrees of freedom, will lead to unimaginable discoveries, beyond human capability. Elements of quantum mechanics will tell us how to arrange these elements into a design, or *no design*. It may become the process of nature in a time warp.

In the consideration of *no design* is the concept of the *original machine,* using a computer and computational tools to holistically integrate design, fabrication, and controls in order to overcome a collection of prefabricated parts or *free form* approach. Paradoxically, this is an emergent design built upon an intention of design, something beyond the capability of a human designer. A *perfect design* from *no design*, given limited human involvement is required. Can we find this use of emergence in the capacity of high powered supercomputers to work our way from out of this morass of technology moving so rapidly that it destroys economic markets through a loss a labor? I think so, and this is the beginning of the supply chain design that shows it as such.

Material Genome and Generative Customization

Major technological advances are in store for us through the use of supercomputers to digitize material properties, and then the design of new materials and products. An initiative to digitize and deploy large scale accurate information to the materials development community will accelerate the discovery of new materials and products (Jain et al. 2013). In the U.S., the Material Genome Initiative was launched in 2011 as collaboration between material and computer scientists to deploy proven computational methods to predict, screen, and optimize materials (National Science and Technology Council 2011).

As is noted above, the current state design and development process is painstakingly long due to the significant trial and error, largely due to material and product design being a complex and multi-dimensional optimization problem with the data needed to make an informed decision on choices usually not in existence (Jain et al. 2013). However, in the future, material properties will be solved upfront using the fundamental laws of physics and chemistry and then digitally formatted and designed *in silico* (Jain et al. 2013). Today, this effort is just in its days of infancy, with great computational power required in the future in order to calculate and store all of these materials. The process itself to *crack the design* of these materials are *computationally expensive* (Jain et al. 2013), and today requires human intervention in order to ensure the results are validated, but this will change in the future.

Over 33,000 materials have been mapped at present, and as is shown in Fig. 3.2, progress continues to grow significantly. Eventually, the focus will be on the calculation, design, and development of novel compounds and alloys unknown to Man today. One day, hopefully in the near future, a product designer will have an idea for a modification of an existing product, or a wholly new product or material altogether, and go to the Material Genome system with certain criteria. Parameters will be input and predictions of compounds will be completed, with potential materials being further explored. From this virtual exploration phase, promising materials will be found, and stability and synthesis testing will be conducted in relation to the new design (Jain et al. 2013). This rapid prototyping and iterative process could transform the design process from 10–20 to 2–3 years (National Science and Technology Council 2011), or even instantaneously through peer designers!

Improvements in design will not only factor in superior function and usability that are topics of importance to today's material scientists, but material scarcity and reuse as well, which will be more important in the twenty-first century frictionless market that must be concerned as well about the environment and a growing population.

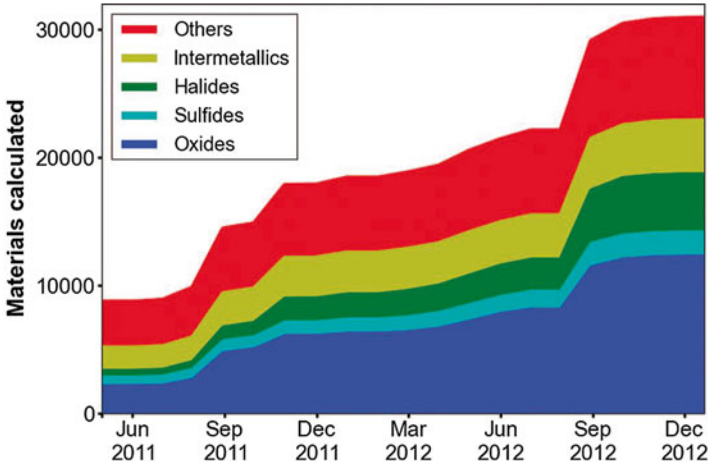

Fig. 3.2 Materials mapped (*Source*: Jain et al. 2013)

Today, each person in the U.S. consumes 25,000 lb of non-fuel minerals each year (National Research Council 2008), and most of what is consumed in products is not recycled, such as electronics waste, and various plastics. User friendly informatics tools that can express the complexities of material hazards, toxicity, and reusability through a systematic scientific and engineering approach will change the way we design, manufacture, distribute, use and reuse products in the future (Ogunseitan et al. 2013).

The Material Genome Initiative (MGI) introduced by the White House in 2011 is very important, from a materials science standpoint, but it does not factor other aspects of supply chain critical to our needs in the twenty-first century. In contrast, my research in the *Generative Customization* concept began in 2009 from an overall supply chain standpoint. In 2009, while I was a doctoral student, I began to develop my dissertation thesis in this topic in order to develop a mass scale alternative to the concept of mass customization, which was not successful in transforming the mass production twentieth century economy. As is shown below, my concept of *Generative Customization* is based upon a marketing and supply chain discipline, versus a material science approach for the MGI, but they have similar characteristics in design and approach. In Fig. 3.3, Generative Customization commences with an understanding of the design of the product using a *product design genotype* in order to use the coding of the gene to develop new design parameters from existing design. From this, structures and functions can be self-organizing and emerge through a generative process.

Next, a national library of product design genes are solicited, acquired, categorized and distributed, as shown in Fig. 3.4 below (Buffington 2010). In this repository is a push and pull process that leads to more product design possibilities.

Next, at the company level, there is a gene library established for product designers, as is shown in Fig. 3.5. In this gene library, emergence and self-organization can

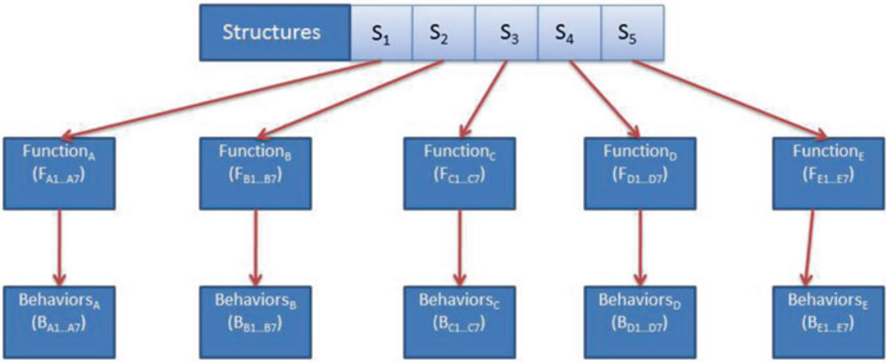

Fig. 3.3 Product design genotype (*Source*: Buffington 2010)

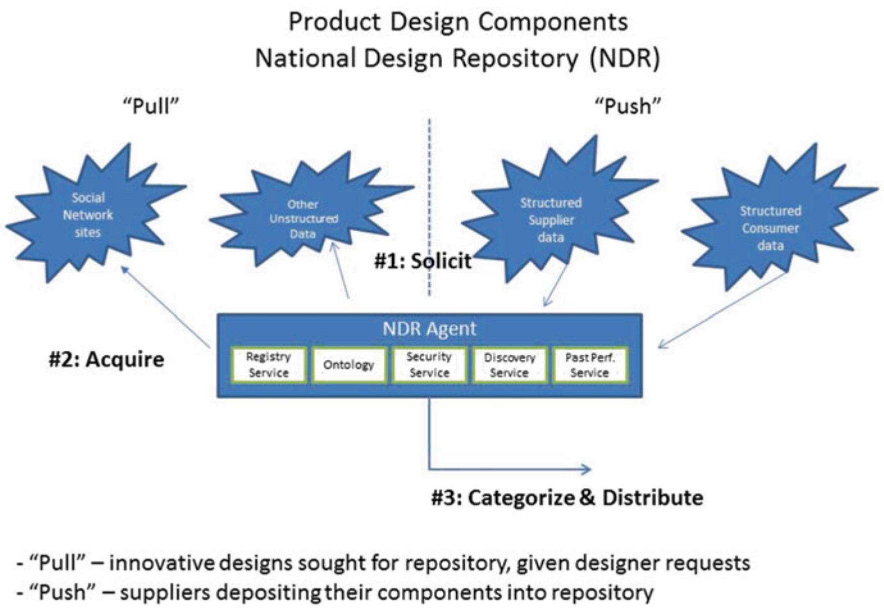

Fig. 3.4 National product design library (*Source*: Buffington 2010)

begin in the company's supply chain, and not just from a material design process. As I will discuss in later chapters, this is the beginning of a different type of supply chain system: one that is self-organizing and emerges rather than a stiff, linear and pre-determined supply chain of the nineteenth and twentieth centuries.

Next in the process, I developed a human-supercomputer iterated process to *mutate design* in order to improve results, as is shown in Fig. 3.6. A new population

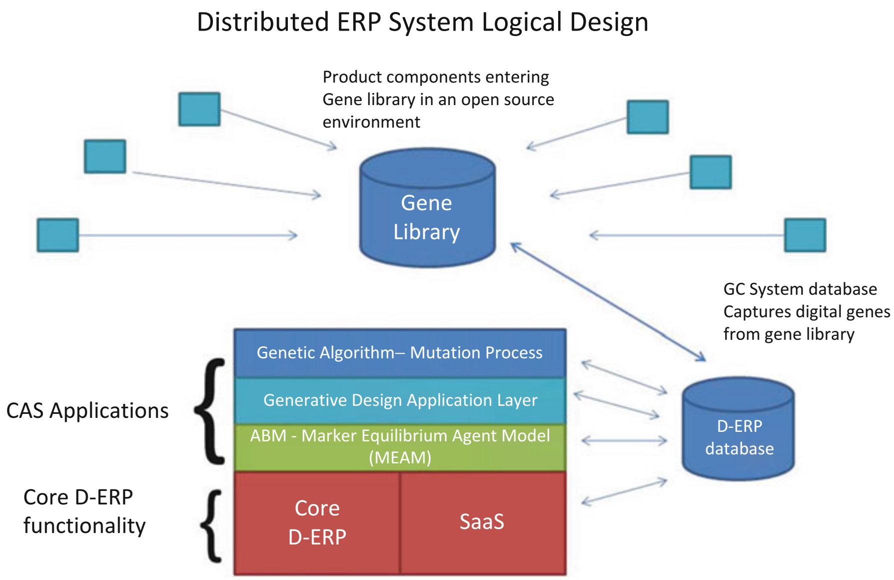

Fig. 3.5 Gene library concept (*Source*: Buffington 2010)

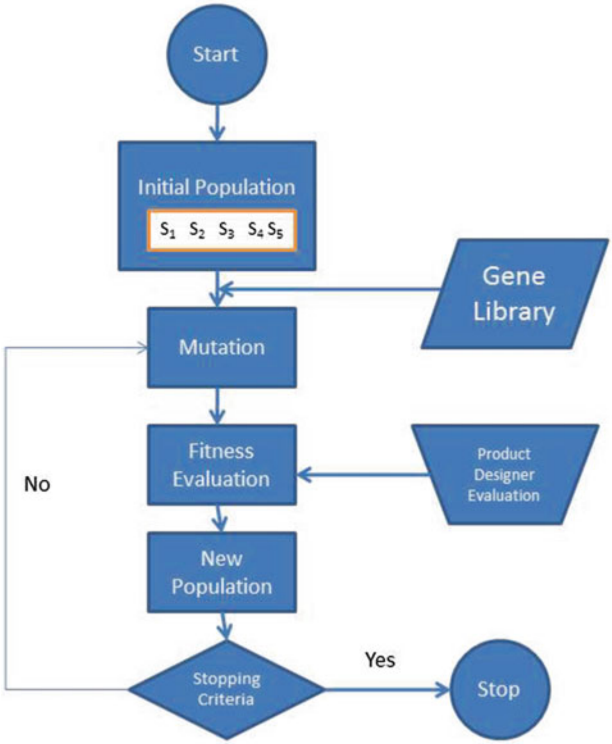

Fig. 3.6 Product design mutation process (*Source*: Buffington 2010)

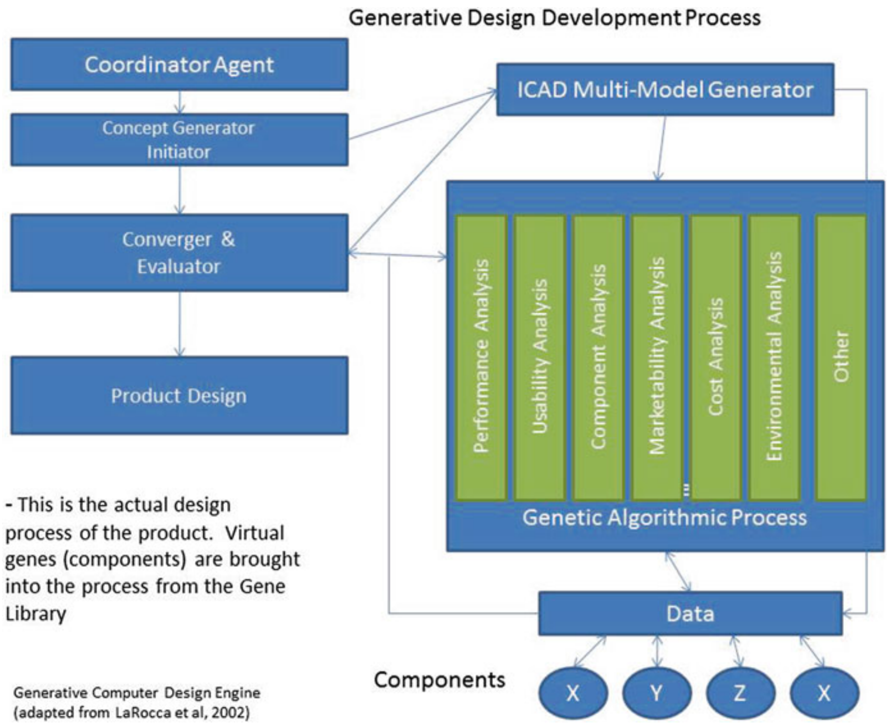

Fig. 3.7 Generative Customization process (*Source*: Buffington 2010)

of product design parameters is developed in this fitness stage, which enables the human and computer to both interface into the design.

More specifically, this Generative Customization process is shown in Fig. 3.7; not only is the design of the product driven through the use of supercomputers, and aspects of the product design considered, so are other factors as well, such as usability (consumer insight), cost, component analysis (manufacturing), marketability (distribution and retail), environmental and others. Therefore, while the MGI materials design process is focused on new materials in order to develop novel innovations, it only considers the material science aspect of the process. The Generative Customization process considers all aspects of the product design, starting with design, and ending with the product's environmental impact in reuse or disposal.

For twenty-first century frictionless markets to occur a new market model must transform; one in which accelerating technology is embraced and enables economic welfare for all involved and environmental sustainability, like exists in nature. This must begin with the design process; a process that acts like, but doesn't necessary mimic nature. Nature must be seen as a process to replicate, not a bunch of infinite resources that we exploit to use within our static, stale nineteenth century supply chains. Design must become a process that exists like nature, not one that seeks to copy it; we must extend our systems beyond the metaphor!

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Chapter 4
Frictionless (Good) Materials

The Revenge of Malthus

Thomas Malthus was a nineteenth century economist best known for predicting the demise of civilization through an increase in population that could not be met by natural resources and the means of production. His famous quote was "the power of population is infinitely greater than the power in the earth to produce subsistence for man" (Malthus and Appleman 1976). Although he predicted the demise of resources and population growth just before the Industrial Revolution when the utilization of fossil fuels led to an extension of the ability to manage large population growth (*Big O*), his ideas have a lasting purpose to our *economic problem*, even today. Since Malthus, the issue of resource exhaustion has remained a significant topic of debate, from a scare that the industrialized world would run out of coal in 1865 to the Peak Oil concern of today, and others. Yet despite the debate and economic forecasts, coal and oil prices have remained constant throughout most of the twentieth century until recently when confidence in the long-term supply became of concern (Palmer 2010). The question now is this: when do we reach the point when a material runs low and a replacement is found versus when we reach an end that leads to an economic catastrophe? When is it that an economist or ecologist a *chicken little* for promoting *doom and gloom* and when can the innovator no longer devise the next alternative in time?

How many of us understand, or even think through the challenge of neoclassical economics that expects infinite growth without infinite materials? Whether it's our supply of fossil fuels that may or may not have suitable replacements in time, wars over water, or the "seeds of technology", rare earth elements that are becoming increasingly important in smartphones, hybrid cars, wind turbines and medical equipment, we need to better understand what's happening in our industrial supply chains of today. In fact, our smartphones can contain over 60 of these metal elements in its design (Newitz 2013), often in trace amounts of materials that cannot be efficiently recycled or metals in rare supply. Today, China, which produces over 90 % of many of these critical high tech materials, is noting that its mines may be

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exhausted in just over a decade, which is also the prediction for other materials, such as silver. In various studies, Yale Industrial Ecology professor Thomas Graedel and his colleagues analyzed alternatives for the 62 metals in industry today: of those, 12 were found to not have any substitutes at all, while none were found to have a substitute that was successful for each of its present day function (Graedel et al. 2013). In some cases, it is believed that substitutes may lead to degradation in performance for some of our high tech inventions, which of course, could lead to a down spiral of Moore's Law rather than an escalation of it.

Economic models exist in regard to natural resources and its *known reserves* that fluctuate over time, given factors such as government policy and market prices. The same applies in the substitution process: as one material becomes rarer, it can increase the value of a substitution sufficiently to make it economically efficient to mine. Cryolite is a mineral that, according to the United States Geological Service (USGA) had no suitable reserves, and was critical in the processing of aluminum. However, alternatives have since been found, and in reality, there are still deposits of it, but it isn't economically viable to extract at the present period (Palmer 2010). Given our exorbitant use of materials in our industrial model, we are putting a large stress on a process to find alternatives to critical materials more so than improving how our products are designed and reused. Today, the average American buys over 2200 lb of material per year; 80 % of these materials end up in incinerators, landfills or as wastewater, and less than 1 % of what we extract is still in use in 6 months after its sale (Wiens 2013). A production and consumption model of significant use and waste, plus complex design (e.g., smartphones requiring over 60 critical materials) are the critical problems that needs to be addressed in the twenty-first century supply chain system, and will require transformation in our frictionless market model.

I was taught in business school that Malthus was wrong because he didn't understand innovation and replacement materials, but there is another part of the equation that must be taught as well: how on a finite planet with an accelerating world population, he will end up being correct *if we do not change our production and consumption market model*. Regardless of innovations in material/resource substitution, today, we are using 50 % more resources than the Earth can sustainably produce or manage (Ridley 2014), and this number is only increasing. For example, fertilizer required to grow crops for a planet of seven billion plus people, given current economic principles, is in demand for phosphorus, yet scientists from the Global Phosphorus Research Initiative predicts that we could run out of the element in 50–100 years unless new reserves are found (Ruz 2011). Will a day arrive when innovations and efficiency improvements will no longer enable us to avoid resource limitations? Under our current market and economic system, the answer is unquestionably yes. So far, we keep proving the Malthusians wrong: the replacement of fire with coal, the scare of limits of coal in the mid-nineteenth century mitigated with better mining techniques, a replacement of dwindling whale oil with kerosene for illumination, and then being replaced with electricity, the limits of U.S. petroleum with other sources, better production/refining techniques, and fuel efficiency, and just recently, the discovery and use of shale oil *fracking*, and an increase in renewables. Even in mineral use, we use 100 times thinner gold plating on computer

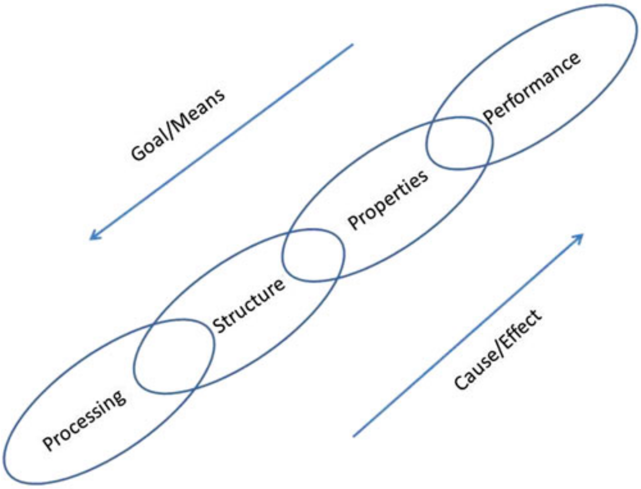

Fig. 4.1 The materials paradigm

connectors than we did 40 years ago, and the steel content in cars and buildings is declining (Ridley 2014). Yet our innovation machine cannot possibly keep up with how fast we are consuming and wasting materials in a system not defined for a population of seven billion and growing!

The Twentieth Century of Synthetic Stuff

In human civilization, technological innovation has almost always been largely about materials; from the Stone Age to the Bronze and Iron Age, all the way to our present time and Silicon Valley driving the twentieth century computer age, materials have been critical to development. Materials are growing more prominent to our civilization, not just within a human civilization era, but a geological epoch as well; the Anthropocene is defined as an informal geological era where human activities have a significant and permanent impact on the planet. The proof of this is evident: the growing prevalence of manmade permanent buildings and structures taking the place of nature, as well as an influx or perhaps, infestation of manmade materials, such as plastic, in the oceans. For us businessmen and economists who calculate natural resources and industry's impact on the environment as within the *ceteris parabis*, or a non-factor, it will be important to better understand materials and material science in the twenty-first century for both economic and environmental reasons, as will be discussed in this chapter.

A material scientist view of the world can be generalized in a *material paradigm*, as is shown in Fig. 4.1. This provides a tetrahedron of five parameters important to its usability in various products. Structure, at the top, is probably the most important of these parameters for material scientists to understand. The structure of a material considers the substance from its atomic level up to its macro scale. The characterization of a material is how material scientists are able to examine the structure of a material, with the tools that are best suited to do so. Looking at a material at an atomic or even sub-atomic level enables the scientist to understand its electrical, optical, thermal, magnetic, chemical, and mechanical properties. As was discussed in the last chapter, the role of a scientist versus a *designer* in the future will be blurred, as will the role of a human versus a supercomputer in figuring out an optimal design of a material, or even what material to use in itself.

As scientists increased their knowledge of the *Materials Paradigm* and an understanding of how to design and use materials in our modern world, materials in products migrated from those stripped from animals (furs and bones), to those mined and processed, and to those grown and harvested to materials that are synthetically produced for a specific purpose. As an example, when rubber tree plants proved itself as an insufficient source, it led to the development of synthetic rubber, being that of a thermoset plastic (Freinkel 2011). Glass that is made from melted sand, for the most part, has since been effectively replaced, in the beverage industry, by PET plastic, a synthetic, fossil fuel based polymer. The question that must be asked is this: in our twenty-first century supply chain system, does it matter economically and environmentally, whether a material is natural or synthetic? As an example, both can be polymers; one can be extracted from nature (such as the use of tree latex, bones, whale blubber and tortoise shells) while the other is processed from fossil fuels (mainly oil and natural gas). Is the use of plant cellulose, often used before the oil boom, a *green plastic*, and does it really matter anyway? In the twentieth century, it mattered a lot because these new synthetic materials were viewed as the ultimate progress against nature, being safe, light, more functional, and easier to manufacture. Since these synthetic hydrocarbons were products using a feedstock of oil and natural gas, already critical to the transportation industry, the petrochemical industry became a *win-win* of functionality and synergy with energy use. The diversity and versatility of the properties of plastic polymers led to a wide array of products that brought technological advances, energy savings, and other benefits to society (Andrady and Neal 2009). And yet as this industry undertook a massive growth phase, few asked the question: are these new synthetic products making our planet, and therefore, our economy, a better or worse place for today and the future?

Generally speaking, the natural curing of polymers for use has been conducted for thousands of years, but it wasn't until the vulcanization process of rubber started in the late nineteenth century when this *chemistry conundrum* began to take shape. I call this a *conundrum* intentionally because while a hydrocarbon from oil or natural gas is molded (plastic comes from the Greek verb plassein, "to mold or shape") into plastic, as long beautiful molecules, it essentially becomes a non-renewable resource as these forms are beyond nature's ability to decompose. After World War II, these long, beautiful, and functional hydrocarbons proliferated into our lives, nearly quadrupling from 213 million pounds in 1939 to 818 million pounds in 1945 (Freinkel 2011), and then exploding even further to its point today. In the midst of this short period of U.S. history, it was found to be the case that the possible applications

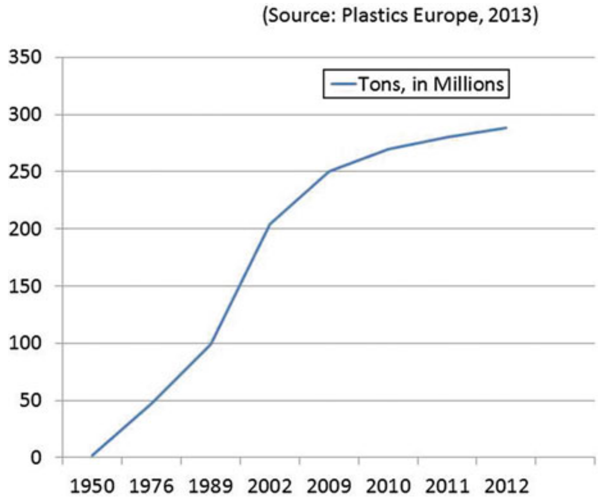

Fig. 4.2 Plastic production (*Source*: iftf.org)

for plastic are almost inexhaustible (Yarsley and Couzens 1941) and this has been proven to be so today. Today, there are 20 different groups of plastics, with each grouping having different sub-sets of grades and types, and an uncountable number of products in our use (APME2006 2006). As is shown in Fig. 4.2, its production and consumption growth has been enormous, while its recovery for reuse has been flat to declining, which suggests it is not complimentary to a greater utility beyond one time use. In modern day economics, the rebuttal to this phenomenon of *one time use and disposal* has been "economics first", but in the future, we must develop the concept of a material that is produced and does more good than harm; that is not just *harm neutral* (which is what the environmentalists often seek), but rather *use positive*.

Before I present a storyline of the *materials of the future* that are *use positive*, I must address the problem that too many of us do not adequately understand: what is a bad use of materials, and why should it matter to us? And while this is a broad topic that could cover an entire book in itself in discussing many of the materials from industry that follow a similar pattern of use and reuse (as little as 1 % reuse), I will focus on the most important material of our age, and perhaps the greatest purveyor of harm: that of plastic, and often its one-time use in the packaging industry.

As a reminder of how nature manages materials, there is a circular path in an ecosystem where an organic material is an output that becomes an input for something else; perhaps the best known example that we are taught in grade school is the photosynthesis process where plants release oxygen for mammals to use, which then returns the favor to send back carbon dioxide to them for their own metabolic process. Nature is a circular economy, so to speak, one that only uses what it needs, and then recycles what is waste into other activities. Plastic is a synthetic material that is foreign to nature, and as a result, cannot adequately biodegrade when disposed, which is done so in staggering amounts every day. While our municipal trash systems are super-efficient in disposing of waste, it is inevitable that spillage will unintentionally seep into our natural ecosystems and damage wildlife; in just one area off the coast of California, a study found that fish ingested 12,000 t of plastic in a year, and plastic has impacted 663 species of birds, fish, and other animals (Beatty 2014). A UNO study found that 18,000 pieces of plastic are adrift on every square kilometer of the world's oceans, and there is more plastic in these waters than plankton to eat. Even as far north as the Arctic Circle, it is found that hundreds of particles per square meter of plastic is trapped into the frozen ice, a surprising statistic, given the lack of human activity in this region (Hand 2014). The problem is in the enormous spatial and temporal heterogeneity of plastic debris (Ryan et al. 2009), and is a problem especially difficult to address (Gregory 2009).

If you're not overly concerned with the impact of plastic in our natural ecosystems and animal life, perhaps you will want to understand its potential impact on our bodies through unintentional digestion, even at the smallest level of leeching exposure. Much to the same as how it is inevitable that the ubiquitous use of plastic will unintentionally leech into our oceans and wildlife areas, the same is potentially the case for our use and our bodies. While plastic is a synthetic hydrocarbon that is designed to not decompose, per se, there are questions on what exactly this means, and whether trace amounts are breaking down through our uses of it in our daily lives. Studies have found that harmful chemical additives such as phthlalates, bisphenol A (BPA) and others can be either directly ingested, such as a baby toys, or unintentionally through packaging or other products (Wagner and Oehlmann 2009). Various papers have shown strong evidence as to why there are concerns regarding the chemical impact of plastic on humans (Thompson et al. 2009). While single use plastic bottles do not contain any polycarbonates, there are still health concerns with leeching, especially if the plastic is heated, such as sitting on a hot delivery truck or your car prior to use. There are numerous and undisclosed chemical additives to plastics by manufacturers such as "plasticizers", which are softening agents to the polymers, which makes it very difficult, if not impossible, to understand its impact on our use.

Good and Bad Materials

In regard to material usage, the present day concept of *sustainability* is more about doing *less harm* than it is *doing more good*; after all, if plastics are recycled, we consider this to be a *sustainable* act, even if the material is not designed from a *cradle to cradle* standpoint, to coin the term of German chemistry professor Michael Braungart. To Braungart, our goal in *The Next Industrial Revolution* is to design and use materials that can *do good* for the environment, society, and economy, and not just do *less harm*. Contrary to the environmentalists, who believe we should reduce our environmental footprint and use fewer materials, Braungart believes we should have a big footprint, and make it an optimal one for the environment (Mother Jones 2008).

As an example, a packaging wrapper could not only be biodegradable, but also contains seeds so that it assists the environment upon disposal. Braungart notes that the paper industry in Europe and the U.S. has been recycling for over two decades in the former, and one in the latter, with no real benefit because they haven't change their toxic inks (Mother Jones 2008). The problem an "ethical" (regulatory), rather than a market argument is the former can become fuzzy; politicians like Al Gore can promote environmentalism without specificity to supply chains and markets. Braungart's position, from one of science, matches the position of this book from a supply chain standpoint: focus on materials that improve the environment and the economy, therefore taking a market rather than an ethical position to solve the problem.

Consistent with this position of an ethical argument in material use ties to a *green approach*; today's bioplastics, for example, are simply an *organic foreign substance to nature* that cannot be recycled or biodegraded rather than a petroleum based foreign substance. At present, there is no empirical evidence that demonstrates that today's use of bioplastics is more environmentally friendly than petroleum based plastics (e.g., Tabone et al. 2010). Not only are bio-plastics technically biodegradable, but so are petroleum based plastics; the *fine print* to the conversation is the conditions that are required in order for the process to occur. In most cases, these materials require a tightly controlled environment or moisture and heat in order for biodegradation to occur, which is different than what happens in disposal. As such, given the low value of these materials as a one-time use water bottle makes it prohibitive to recycle, or even produce as a bioplastic, and the different compositions of polymers (e.g., different types of bioplastics and petroleum based polymers) leads to lower recycling use rates due to the higher costs associated in doing so; recycling becomes a supply chain problem.

A comparison of bioplastics to conventional petroleum based plastic is an example of how today's materials are not designed for reuse, or as Braungart calls it an improvement to the environment. Today, there is a growing acceptance that materials that are organic are good, and those that are not are bad, but the truth is never so simple to define; instead, we must be able to define and use materials in good ways, and therefore, without concern because the more use will lead to improvements to the environment and economy.

Future (Good) Materials

Before a discussion of *good materials* that can enable transformation in our twenty-first century frictionless markets, I must address the frictions that are in place today in regard to these bad materials. First, we must escape the notion from an economics standpoint that natural resources are infinite, and we can continue to design and use these resources in a wasteful manner. For example, the material of plastic has effectively been invented and designed for waste, not reuse, so any efforts to recycle this material is an ineffective exercise, or as Michael Braungart notes, "an effort to reduce the bad instead of *designing for good*." We should design materials for reuse, not waste, which will improve results from an effort on the front end rather trying to solve the problem ineffectively on the back end.

Next, should it matter to us whether our materials are in harmony with nature, or as the question is often posed: which is more important, the environment or the economy? From my definition of frictionless markets, and supported by Braungart, this is a rhetorical question: a market model that enables economic growth is the only way to improve the environment, not the opposite. Therefore, in the new frictionless market model, materials are designed for good, not bad, to the economy and environment, which leads to greater opportunities for improvement for both. Next, is the question of how should these materials be designed: by material scientists, industrial designers, supercomputers, or a combination of the three? The answer to this question is a combination of the three, but with the supercomputer as the foundation of the process, just as calculation is the basis for DNA development. In order for our future materials to do well, it must be *designed for good*, taking into consideration a multitude of parameters that is not possible to calculate through human minds. The materials of the future need to emerge, *in silico*, rather than be developed using a few parameters, and everything else deemed as unimportant.

The first *good material* may be graphene, a single atom thick carbon crystal material that is effectively two dimensional. This material is 100 times stronger than steel, the thinnest material possible, flexible, stretchable, and the most conductive substance ever seen (Geim and Novoselov 2007). Since this material is made from the most abundant organic element on earth, carbon, it is renewable and extensively available, and now scientists are learning to use graphene on a variety of substances and uses, with many more on the horizon. Potential solutions that we can hypothesize today will likely be viewed as primitive in the future: think of the bounty of carbon to be used as a conductive material for solar energy, as an effective tool in turning sea water into drinking water, and also as a transporter of energy as well as conductor of it. Due to the property of carbon and the ability to create a 2D crystal, the possibilities for the future seem almost endless!

Another nanotechnology material that can be a game changer for the future is nanocellulose. In this chapter, I discussed many, but not all of the problems associated with synthetic and bioplastic plastic as a material. In the late nineteenth century into the middle of the twentieth century (such as the invention of the PET plastic bottle), plastics have been designed and used as a perfect alternative to organic polymers; however, with the gift of hindsight, we can look back on the past and see the misgivings in our design use, and then overuse of plastic. Of course, back then, we didn't have the tools that we have today, most notably, the ability to make nanomaterials that possess better characteristics than our present and past day 3D materials of nature. Today, with the advance scientific knowledge of nanotechnology for use in non-food celluloses, such as wood, various grasses, and even cellulosic waste from *farms*, *fields*, and *factories*, there is an opportunity to develop the next generation bio-polymer or bio-plastic to rid our world of packaging waste that threatens our environment. In my career, I have had the pleasure to work with noted scientists in this field, who are pioneering future materials that will change how we package our products, and other fields such as medical, transportation, and even electronics. Most important to me is to rid ourselves of packaging waste, which I have calculated to being over 600 million containers a day in the U.S. alone. Packaging applications with strength, tensile, gas and oxygen, and thermal requirements to manage our beverage consumption, and in the end, to be a material that can either be biodegraded or reused, will be a game changing material in the twenty-first century frictionless market system.

The last nanomaterial that I will discuss is an application for the potential of a battery efficient and affordable enough for use in a reasonably priced electric car to have a 300 mile range, or a smartphone that can triple its battery life. Today's design challenge is in the use of a lithium ion battery to achieve a *pure lithium* battery through the use of nano anodes; today's existing lithium ion battery has a silicon or graphite, and the electrolyte component is lithium. A pure lithium battery would have superior energy density and lower the cost, but the issue is that today's design of lithium ion, the anode would expand much greater than the silicon or graphite anode, leading to cracks and damage. To prevent a lithium anode from expanding, a Stanford research team has developed a protective layer of carbon domes in a nanosphere on top of the lithium anode (Zheng et al. 2014). Accomplishing the development of a pure lithium battery through this stabilizing use of carbon nanospheres could usher in a new era of battery power, or even energy in general, both increasing its energy density sufficiently for wider scale use of electric cars (farther ranges) and lowering the price of these cars to make them more affordable to the average consumer. Furthermore, other opportunities for energy storage and use through batteries seem to be endless as well. This is an example of a *good material* that could transform the twenty-first century economy.

Through nanotechnology and supercomputer designed materials, there is a virtually endless array of *good materials* of the future. Through the use of nanomaterials such as graphene, embedded electronics will take form, including organic polymers that conduct electricity, which could provide electronic equipment that is truly a part of a circular, recyclable/reuse system rather than consisting of 60 trace amounts of expensive metals that must be trashed after its single use. Researchers at three universities (University of Massachusetts, Stanford University and Dresden University of Technology) have developed an organic nanostructure called "nanograss" that is a dense array of nanopillars that may lead to a cheaper, advanced, and sustainable way of capturing sunlight and turning it into electricity for storage devices (Borghino 2014).

Other materials that will transform the twenty-first century through *good materials* is the use of programmable matter, or matter that self-emerges, or changes physical properties, such as shape, density, conductivity, etcetera) based upon user input or a sensor; this would lead to more efficient use of materials, given today's materials are limited solely to a specific function based upon its *materials paradigm*, leading to more materials. Consistent with this concept of alterable materials are multi-ferroics that can manage the electric field and magnetic state of a process more efficiently than is possible in data storage devices. Aerogel is a material, as shown below in Fig. 4.3, that is 98.2 % air and the remainder often silica or carbon that is structured with air pockets to be almost weightless. Today, it is primarily used for insulation, but the potential for this in the future will be much greater, given the

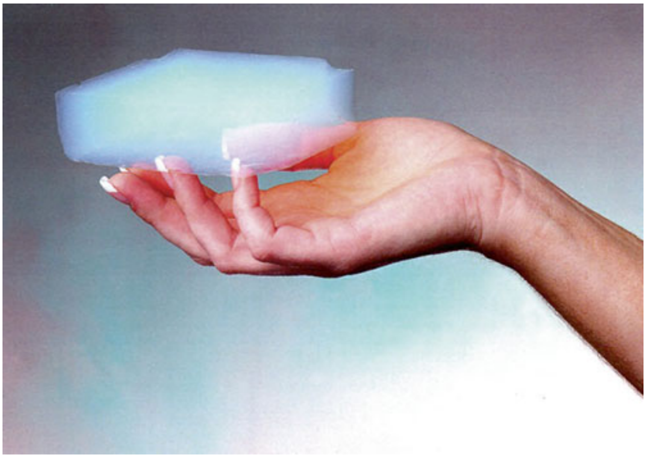

Fig. 4.3 Aerogel

material's properties of density and thinness. In the future, Aerogel could be used, alongside nanocelluloses, to rid the world completely of today's unsustainable plastic with a 100 % environmentally friendly material. Through its future ability to both reduce energy use through cheap and effective insulation, and a potential replacement of plastic, aerogel will definitely be a *good material* of the future.

Especially given the use of supercomputers as the primary designer of our future materials in order to optimize their use and reuse to improve both the economy and the environment, is the concept of a *metamaterial*, which is defined as a material that possess electromagnetic properties that do not exist in nature (Nader and Ziolkowski 2006). Through their shape, geometry, size, orientation and arrangement, these materials can affect waves of light, incorporating structural elements of sub-wavelength sizes that can improve supercomputer chip processing speeds and capacity, beam Internet access anywhere, and replace the high speed fiber-optic telecommunications network, game change camera lenses and make solar energy more efficient.

This list of *good materials* is far from extensive, to say the least. In Chap. 2, I quoted economists as contending that an *end to growth* will occur due to all of the obvious innovations being achieved in the twentieth century, the *one-time lottery ticket*. But the materials of the twentieth century will pale in comparison to the possibilities of the twenty-first century materials, many of them that we truly don't understand today, but will in the future when our *concept of design* changes through the power of supercomputers. In summary, these twenty-first century materials will do the following not possible in the twentieth century with its materials:

1. Materials that make both the economy and environment better; these two will no longer be mutually exclusive.
2. Materials mostly made from less scarce (carbon and silicon versus rare earth metals) and reusable materials.

3. Materials that can be assembled at a nanoscale and can be emergent.
4. Materials that defy our current definition of a material by being 2D versus 3D, or existing of 98.2 % air.
5. Materials that are 100 % biodegradable and reusable.
6. Peer materials; materials that are defined and emerge from a sociocultural definition rather than only a scientific/engineering standpoint.
7. Materials beyond our current understanding.

I predict the future of the twenty-first century supply chain will lead to greater, not less growth, than in the twentieth century, not because "all of the great innovations have been determined", but rather due to a transformation of materials, ushering in a new age of economics and environmental balance! The twenty-first century will be a new era of transformation through materials!

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Chapter 5
The Future of Manufacturing: An End to Mass Production

Brain Center at Whipple's

Once upon a time, there may have been a fantasy of a *leisure society*, and a 15 h work week, but no longer. Perhaps the fantasy began to end when the first industrial robot was installed on an assembly line at a General Motors plant in New Jersey in 1961, and this *love/hate* fascination with automation and employment has been on our minds ever since; the largescale automation of labor has been around for over a century, even though some of us believe it's just a recent phenomenon. It continues forward, as I will discuss in this chapter, and today, it has reached a tipping point when something needs to be done, given its impact on labor markets. A continuation of technological progress will be the easy part; the harder challenge will be the societal impact caused by a world without work.

In 1964, just a few years after the onset of GM automation, the popular television show, "The Twilight Zone" provided a bit of prophecy in an episode titled, "The Brain Center at Whipple's." In this episode, the owner of the manufacturing company, Wallace Whipple upgraded his factory in order to increase output by installing a "X109B14" machine, at the dismay of the workforce. Workers at the factory took their opportunity to warn Mr. Whipple of the dangerous impact of automation, but in each instance, he considered them a modern day Luddite, and unceremoniously laid them off, no longer needing their services. Finally, the board of directors found Whipple to be obsessed with these machines, and ironically, replaced him with a robot. At the end of the program, a silly 1960s version of a robot manager was shown doing the same job as poor old Whipple. Perhaps, this episode of the Twilight Zone is more realistic today than many in 1964 would have thought it would be: our white collar workforce that have often endorsed a program of shop floor automation is now being threatened by the very same technologies that it had once advocated. Science fiction from the 1960s has become a twenty-first century reality, with the exception of one structural difference: it is the market structure of our economy that should scare us, not the technology that is often viewed as the villain. In this chapter, I will introduce manufacturing as a

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new form of a *peer to peer* economy with automation proceeding forward, but without the worker being kicked to the curb, like what happened to Whipple and his manufacturing operation!

Manufacturing Greatness: The U.S. Story

In his first annual message to Congress, President George Washington said that "(our) safety and interest require that (we) should promote such manufactories, as tend to render them independent on others, for essential, particularly for military supplies" (Yale Law School 2014). Just a week later, the first Treasury Secretary, Alexander Hamilton, was required to submit the country's first manufacturing strategy, which he did in December, 1791 titled, "Report on Manufactures". In this report, Hamilton called for the protection of its infant manufacturing economy since "it cannot exchange with Europe on equal terms" (Constitution Society 2014). Some at the time considered Hamilton's special conditions to protect manufacturing as an affront to the growth and importance of agriculture; American farming was on its way of becoming a world power, but manufacturing was the key to the future, especially given its importance to immigration, innovation, and national defense. In Hamilton's strategy, not only did he believe it was important to protect America's competitiveness with Europe, he felt the greater threat to manufacturing was "the apprehension of failing in new attempts" that should be supported by government in "order to overcome these obstacles" (Katz and Lee 2011). Hamilton's view of innovation and its importance in manufacturing set America upon a long course of success.

Fast forward through American history and greatness past Eli Whitney's Cotton Gin (1801), the first American steam engine, the *Tom Thumb* (1830), and to the first manufactured automobile on an assembly line, the Model T in 1913. Mass production was not just an engine of growth in manufacturing, but an innovation strategy for nationwide and global markets of the future. Prior to the Industrial Revolution, an artisan would produce a product only after the customer made a commitment to its purchase, inevitably leading to higher manufacturing and distribution costs, not enabling growth in scale and efficiency. Through the new mechanization of production, assembly lines, and transportation, work could be *deskilled*, enabling a planned economy that drove greater efficiency and scale, and therefore consumption. In this new model, enabled by technology, production systems and planning were put into place, as well as this *transaction cost* concept that I mentioned in chapter one that led to the necessary frictions of the *Big O* organization, leading to more employment and higher demand. The same auto that could be produced on an assembly line in 93 min in 1914 could be produced every 10 s by 1925! In this model, Hamilton's *Two Is* of immigration and innovation—immigration that enabled the deskilling of work and innovation via mechanization that ensured this system was possible.

For the first time in economic history, production did not constrain demand, and therefore, automation could be unleashed to machine capacity, then leaving it up to the *Big O* of organization to enable a consumption driven economy. Structured manufacturing and marketing processes were put into place, such as scientific management, organizational structure and hierarchy, and product lifecycle management in order to drive efficiency, profit, and growth. The moving assembly line became the start of the Industrial Revolution, with 15 million Model Ts being sold in 19 years of its onset (The Economist 2009). The effects to the U.S. economy were staggering: in 1904, the U.S. auto industry employed 3000 workers, in 1914, it was 67,538 workers, and by 1919, it was 75,000 workers (Winter 1996), and it would continue to escalate. During this same era, Ford increased productivity by 90 % that allowed him to double wages and cut the workday from 10 to 8 h (Winter 1996). By 1955, the Big Three were selling seven million automobiles a year, with the entire nation benefiting from this grand manufacturing combination of the win-win between production and workers. And yet in 1962, as is noted above, the story began to change, and robots started to enter the scene. The problem was not the technology or offshoring itself, although it is often deemed the culprit, but the lack of knowing how to cope to address this opportunity; an example of this emerging problem is articulated through a conversation that CIO Union President Walter Reuther recalls having on the shop floor with a Ford management leader who asked him, "How are you going to collect union dues from all these machines?" Reuther's response was: "You know, that is not what's bothering me. I'm troubled by the problem of how to sell automobiles to these machines." The problem addressed in the Twilight Zone episode and Reuther's shop floor conversation is the same problem we face today: not a problem of technology, but rather of economic structure and markets.

The Curse of Deindustrialization

As is shown in Fig. 5.1, manufacturing reached its peak employment percentage between the 1950s and 1960, and then began its long spiral downward. Economists have filled libraries full of articles that have analyzed this storyline, a problem we call *deindustrialization*. As a young boy growing up in Baltimore in the 1970s, this is an issue that I am personally familiar with; I watched a generation of blue collar workers at the assembly plants and shipyards lose their jobs, and listened to the affected workers blame their misfortune on the Japanese or now the Chinese, not understanding the real culprit of this problem was due to a more complex explanation. Foundationally, economic historians have pointed to America's ability to withstand World War II with no structural damage to its manufacturing engine as a major reason for its later decline just a few short decades later, since its future competitors like Germany and Japan were forced to rebuild with newer technologies and processes. This theory does make some sense, as the U.S. was able to focus its post-war investment into higher labor rates and standards of living while other nations focused on capital investments of its infrastructure, a lower wage operation, and savings rather than consumption. By the 1970s, the Japanese were exporting a third of its steel to the U.S., and after a generation had passed, the young boys who

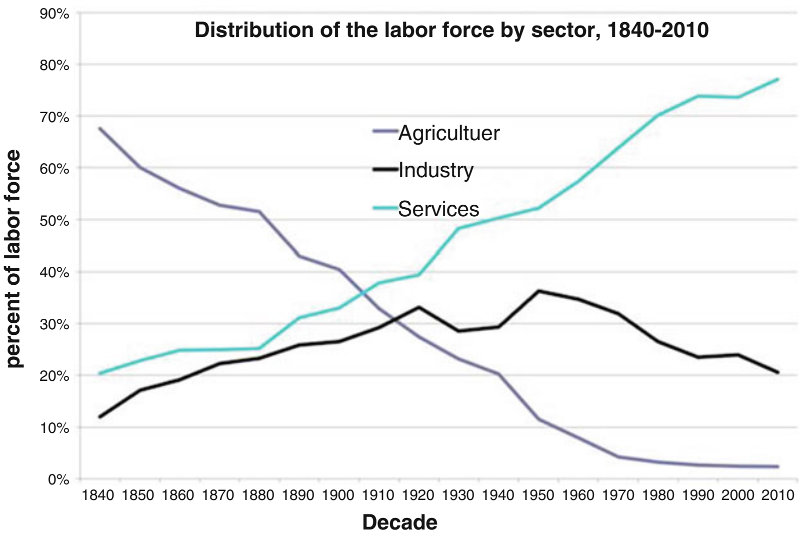

Fig. 5.1 U.S. labor distribution (*Source*: minnpost.com)

were G.I.s in World War II were forced into battle again, this time for their jobs against the Germans and the Japanese. The real problem was not our World War II enemies that were finally renewed after the damage of the war, but rather our misunderstanding of how to retool, not just our technologies, but economic and market structures as well.

As is shown in Fig. 5.1, the manufacturing demise of deindustrialization in America was in collapse mode in the 1980s. As a telltale sign of this, the automakers, which were always the bellwether of manufacturing in America, began to show serious financial strain during this era. In 1979, Chrysler was the first auto company to lose $1 billion in a year, and then the following year, it lost $1.7 billion amidst the pithy Lee Iacocca ad, "America isn't going to get pushed around anymore." Henry Ford II's silly comment in regard to Toyota of "mini cars, mini profits" showed how out of touch his company was, including a lack of innovation, efficiency, quality, and labor issues (Baugh and Yudken 2006). Just a decade later, the problems seemed to mount and frustrations really boiled over when the North American Free Trade Agreement (NAFTA) deal was signed making it easier for suppliers to produce all or part of its operation in Mexico. The face of this mounting deindustrialization was not advertised as the lack of a manufacturing strategy to address these technological and structural changes, but rather the xenophobia of Mexicans, Japanese, and soon to be Chinese who were being "sent our jobs on a silver platter". American success stories turned into nightmares: Nike founder Phil Knight's Master's thesis led to a business model without ever manufacturing a product in the U.S., presenting this latest American innovator into an anti Henry Ford. Somewhere along the road, America's manufacturing strategy transformed from a *multipler effect* in which Henry Ford enabled consumption of his Model Ts through higher wages and

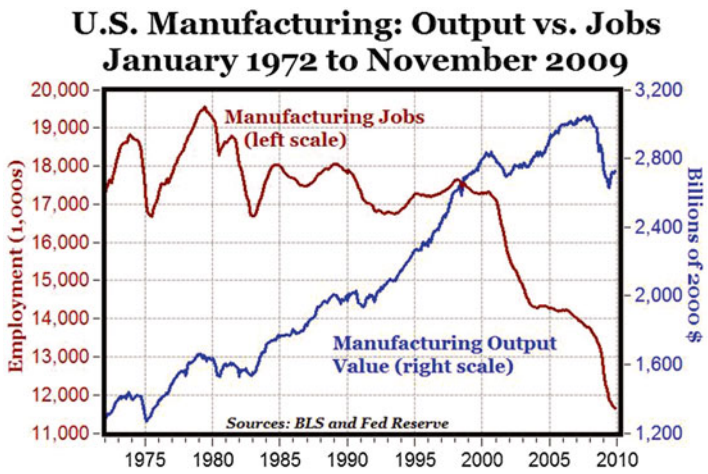

Fig. 5.2 US manufacturing output (*Source*: BLS/Federal Reserve)

production scale to Phil Knight's *divider effect* where American kids bought $100 *Air Jordans* made in the 1980s and 1990s by Indonesians and Vietnamese making less than a dollar an hour, under harsh conditions. As well, while deindustrialization is often labeled as a developed versus developing nation economic problem, Germany's percentage of global exports is 9 % versus 8.5 % for the U.S. in 2009, despite the latter's economy being four times larger than the former (Smil 2011). The problem of U.S. deindustrialization is often classified as a problem of the global economy first, and technology second, yet a deep seeded foundational problem exists that remains unsolved.

Statistics are often misleading and misused in the field of economics, but here are some important ones to understand; Fig. 5.2 tells a bipolar story with respect to the state of manufacturing in the U.S.; while the scale of manufacturing employment has fallen off a cliff (at the same time the population keeps rising), manufacturing output continues to rise. Output shows signs of decline that is related to recessionary periods, but thereafter, output continues to rise. This leads to the first myth that U.S. manufacturing is on a decline; in reality, it is U.S. manufacturing employment, not production output.

An obvious conclusion from Fig. 5.2 is that manufacturing output continues to escalate as a function of capital investment: advancing and less expensive automation is increasingly more efficient than labor rates, even when they are flat due to this technological pressure. As is shown in Fig. 5.3, this is not necessarily the case: fixed capital investments in manufacturing peaked in the late 1960s to the late 1970s to almost 3 %, and then has been cut in more than half up to today. In comparison to other developed nations, such as Germany, Japan, and Sweden, and developing nations, such as China and much of Asia, there is a different manufacturing strategy put forth that cannot be described by accelerating technology or a global manufacturing model.

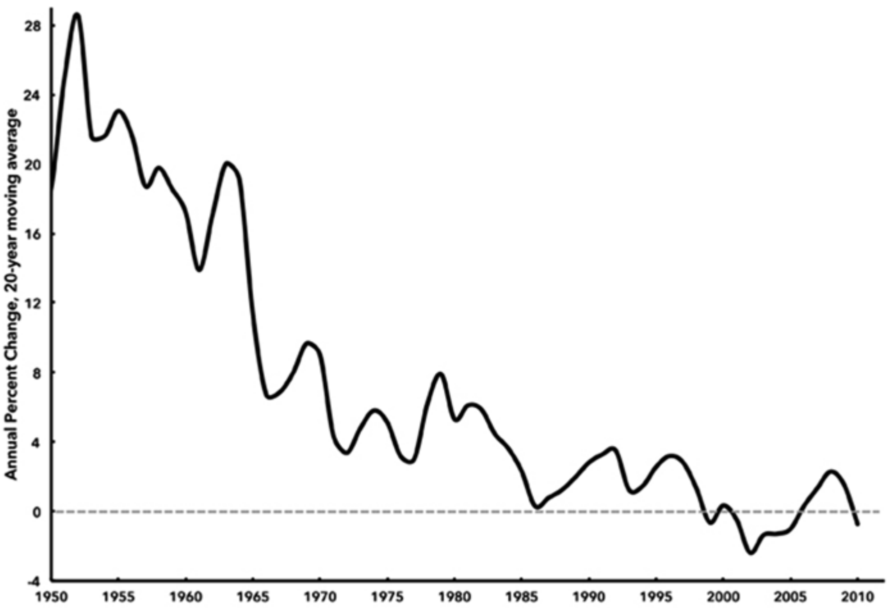

Fig. 5.3 Reduced capital investment (*Source*: Bureau of Economic Analysis)

I believe these statistics presents an alarmingly different picture to America's rapidly declining manufacturing strategy than is typically presented in the conventional media: it is not due to technology that has led to the rapid loss of employment and capital investment, but rather, its dysfunctional policies in response to it. Perhaps due to historically high labor rates and prosperity, America's policies have been somewhat technophobic, which can chase away investment and employment.

Should Manufacturing Matter?

The statistics presents a clear story of a lack of a U.S. manufacturing strategy for the past four decades, which is concerning because manufacturing remains a viable sector in the world economy. The industry accounts for 16 % of the global GDP, 70 % of global trade, and 30–50 % of service jobs stem from manufacturing (McKinsey & Company 2012). Stemming from a lack of investment and strategic policy, an unfortunate conclusion is that a future facing manufacturing strategy is not in place for the U.S., however, in 2000, there were 17.3 million manufacturing workers in the U.S., and 11.5 million in 2010, a 33 % decrease (Acemoglu et al. 2014). The rise of the Chinese manufacturing sector appears to be a logical explanation for this precipitous drop in employment, after decades of decline, with its percentage of total manufacturing climbing from 5 % in 1991 to 11 % in 2001 to 23 % in 2011

(Acemoglu et al. 2014). However, there is a deeper story that I will present in this chapter that is important to understand to change this declining slide in an industry that will become vitally crucial to the future of frictionless markets. Yet if manufacturing policy continues to be viewed from the lens of the twentieth century economy, such declines will continue, leading to manufacturing continuing to fall as a percentage of the overall U.S. economy. An old paradigm exists in thinking that production is associated with wealth producing, developing nation economic activity, while developing nations are focused on the service industry and a consumer based economy. However, a trend is emerging with the acceleration of technology in not only the fusion of products and services, but consumers and producers as well, creating the term the prosumer. In the frictionless markets of the future, a strategy that is only focused on one or the other will be a failed strategy that limits economic growth of all markets.

Technology for future manufacturing will be a smaller, fused, *peer manufacturing* model that extends into the supply chain through the consumer and throughout the economy. As a signal of this future trend, much of the manufacturing growth that has remained in the U.S. after these decades of deindustrialization has been small to mid-sized manufacturers, accounting for 50 % of employment and a total of 300,000 firms (Andes and Muro 2013). This is especially relevant in advanced manufacturing, which accounts for 11 % of the U.S. economy, and 68 % of private sector R&D (Andes and Muro 2013). The data is clear that America's manufacturing policy, at least in the popular media, is obsessed with the large mass production model of the past, leading to movement to other nations, and not investing in the future, which is necessary for the advanced manufacturing of frictionless markets. America's politicians and policymakers need to stop proselytizing for a return to the past, and start building economic and environmental manufacturing strategies for the future.

An End to Mass Production?

It's time for America and other post-industrial economies to completely change their way of thinking related to manufacturing. Politicians and policymakers need to stop drumming up dreams if an industrial policy supporting $35–$50 an hour autoworker and other heavy manufacturing jobs that can never be, and steer policy toward the prosumer, the small, individual producer role in a *peer to peer economy*. As opposed to a Nike *divider effect* model of a shoe purchase enabling a labor model of a $1 an hour in some faraway sweat shop, a transformed market model can be achieved through a model of manufacturing using the prosumer model. This will become a paradigm shift in manufacturing, if we allow accelerating technology to allow it so; the question is, will we?

This new manufacturing model will not be built on cheaper labor, and corresponding technology, but rather sophisticated technology that will enable peer to peer. From the origin of human civilization, our manufacturing model, for a lack of

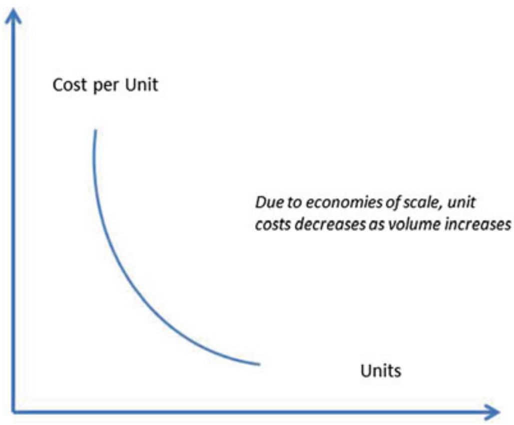

Fig. 5.4 Subtractive manufacturing economics (*Source*: disruptiveinnovation.se)

a better term, has been driven through *subtractive* methods, an ancient idea of finding a hidden beauty or function in a piece of material that has been extended to manufacturing, technology, and education (Brown 2012). In this process, metals, minerals and other materials are extracted from mines and processed, leaving behind the waste residual; quite often, the ratio of extracted to processed material is 10:1, a level of inefficiency that could never be sustained in nature. This process is not only environmentally damaging, but always requires an exorbitant amount of other resources in the transition process, most notably energy and water, exacerbating the process even further. Today, manufacturing is defined using the terms *stamping*, *cutting*, *grinding*, *settling*, *filtering*, and *boiling off* (Brown 2012), rather than additive terms. This "heat, beat, and treat" method that Janine Benyus discusses from her book *Biomimicry*, is the definition of nineteenth and twentieth century manufacturing that has led to such exponential growth, and mass production. As well, a case can be made that human labor has been subtractive in the process as well.

Given the wastefulness involved in mining iron and processing it into steel, for example, a subtractive manufacturing process requires economies of scale, by definition. As is shown in Fig. 5.4, subtractive manufacturing is only successful economically when it leads to mass production; unit costs decrease as volumes increase. Furthermore, it is not just the manufacturing side of the equation, but an overall supply chain system that must be of large scope and scale in order for these large sectors to be successful. And once these sectors reach large scale and scope, they achieve success at levels that may prohibit competition, given the large capital investment to achieve, and the formal supply chains put forth to enable its success. In the nineteenth and twentieth century, the material manufacturers became some of the largest and most profitable industries; oil, iron, and aluminum are examples of how scale has been achieved to support a subtractive manufacturing supply chain, from beginning to end. All of the large conglomerates in these industries faced anti-trust legislation; Standard Oil in 1911, U.S. Steel in 1920 (won its case), and Alcoa in 1945 and others. Today in the aluminum industry, there are a few multinational corporations, such as Alcoa, and nationalized interests, such as RUSAL in Russia

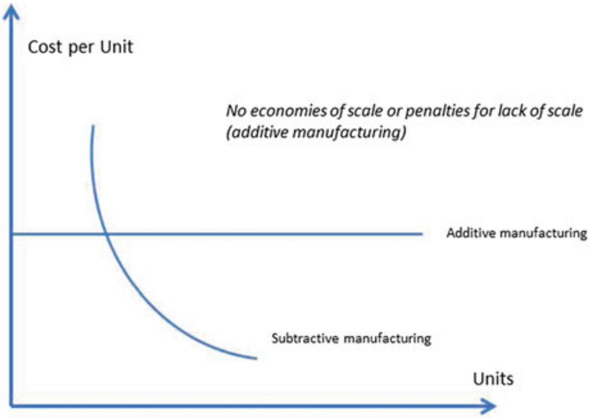

Fig. 5.5 Subtractive versus additive manufacturing economics (disruptiveinnovation.se)

and Chinalco in China, who are responsible for the extraction, processing, and subtractive manufacturing of this metal for uses in the packaging, and transportation industries. Due to their high level of efficiencies and capital investment, the barriers to entry in these industries are prohibitive, making today's dominant materials (iron, aluminum, petrochemicals, oil) advantageous in a subtractive manufacturing model.

Despite the relative success of these material industries to counter anti-trust legislation that is counter to its *raison d'etre*, as is shown in Fig. 5.5, these supply chain systems cannot last, given the trends that are moving in favor of customization rather than mass produced standard products. In this graph, there is the model that each of these strategies are designed to enable: a subtractive manufacturing model is intended to support a capital intensive, mass produced system of lower priced, large scale goods, but its curve will invert if customization is required. In contrast, an additive model is based upon low capital, low volume goods production, and will be competitive to mass production if customization is required. As technology costs fall to enable additive manufacturing, the cost model for this equation can actually fall, especially if material waste is taken into consideration. In a future market model that requires greater complexity, which is demonstrated via customization, but is within a model of scarce resources, there will be an obvious future movement away from mass production toward additive manufacturing.

Every supply chain professional can tell you that today's twenty-first century consumer does not want standardized *one size fits all* goods when she can get customization from another producer, often at the same price. Today, our industry manages this increasing complexity, not at the manufacturing stage of additive, *peer manufacturing*, but rather through the supply chain system in a dizzying and complex array of distribution and retail strategies that I will discuss in the next chapter of this book. Yet the dream of consumer product industries has always been to enable the consumer to produce her customization herself, rather than filling warehouses of goods waiting for a customer to order. When I was an undergraduate in the mid-1980s, I read a book written by futurist Alvin Toffler titled, *The Third Wave*, in which he classified the first wave as the agricultural revolution that replaced the hunter-gather era, and the second wave as the industrial revolution that replaced the farming era. Toffler described this second wave as one built upon mass production, mass distribution, mass everything; everything is standardized, centralized, concentrated, and bureaucratic. In contrast, the *third wave* was a move away from all of this, albeit Toffler's vision at the time was far away from what was technically possible. In 1987, consultant Stan Davis extended the vision one step further through the term, *mass customization* that he wrote about in his 1987 book, *Future Perfect* in which customer needs could be achieved at near mass production efficiency.

For the next 30 or so years, this concept of mass customization was never more than a passing fancy; it was never close to the near mass production efficiency in price and availability that is endeavored to achieve. I found through my doctoral research that the consumer was unwilling to pay a higher price for a customized good when there was increasing selection in mass produced goods; while a fully customized athletic shoe was cool at $350, the consumer was not willing to pay this price, and then have to wait 2 weeks for a clear impulse purchase (as nobody in their right mind would do so premeditatedly). There was also the *analysis of paralysis* defined by Barry Schwartz in his book *The Paradox of Choice*; in the end, most of us do not find extended customization to be liberating, but actually paralyzing. Therefore, for the past 30 years, customization has not had either a technology or marketing strategy to support it in overtaking mass production, but the signs of mass production's demise are the *writing on the wall*. The days of mass production are over. In the future, consumers will require more customization, driven by technology, and producers will be required to be more "supply chain efficient" than mass production can achieve. In fact, I predict that by 2030, people will consider mass production as odd of a concept as we consider handcrafted artisans are today; there will be mass produced goods, but it will be a niche industry, rather than how our products are designed and produced.

The Transition Stage from Mass Production

The *dirty little secret* that many of us in the consumer products industry already know is this: mass production is already on its way out. Some companies, like Starbucks, embrace this concept: it is said that one can order 1 of nearly 100,000 different possibilities at any location, although you may need to help the barista through the process. Soft drink manufacturers used to rely upon a significant percentage of its sales on a few products accounting for 80 % of its sales, such as Coke, Diet Coke and Sprite, now these companies are faced with numerous new products and product extensions (such as flavored Diet Coke versus plain old Diet Coke, or even Coke's new milk product). Large manufacturers are facing this customization challenge in a mass production world, especially given the large influx of small soda companies, microbreweries, book publishers, electronics manufacturers, and virtually everything else. This transition is not overly apparent to us because we still are bombarded by the same large brands at our Wal-Marts and Best Buys, but through advances in manufacturing technology, the days of cheap and quick customization are on the horizon.

In the future, manufacturing platforms will enable the customization, rather than relying upon the supply chain system to handle this process through massive inventory levels. The future will become an end to the *frictioned model* of the balance between production of capital, labor and technology, and its impact on society. This new micro manufacturing platform will revolutionize supply chains and economics, just like the advanced technologies of manufacturing mechanization and the assembly line led to Fordism, an economic and social form of mass production. Quite predictably, these additive technologies of the future that will be discussed in this chapter will set forth a new form of societal change, defined by a form of peer based production. No longer will it be necessary for capital investment to drive economic growth as a function of lower cost advanced technologies, producing small batch, or even single item production. Most notably, is the concept of *3D printing*, is the creation of a digital model and the use of additive manufacturing through the use of lasers to bind materials (Accenture 2014).

This concept of 3D printing will be the game changer in the twenty-first century for peer production that the assembly line was in the twentieth century for mass production. Today, it is used primarily for prototyping, but in the next 5 years, it will be extended for spare parts production and distribution, and then likely in 10 years for the ultra-postponement and customization supply chain and manufacturing process of peer production (Accenture 2014). Over this same decade period, the design re-design, prototyping and final production costs of 3D printing will be reduced in half (Solid Concepts 2014), leading to a new industrial revolution. But technological advancements are only one side of the coin that will be required for peer production to overtake mass production: other factors such as design models and documentation, robust 3D development processes, quality control, test planning, and supported material/assembly complexity (such as electronics embedded in materials) must also take shape (Moilanen and Vadén 2012).

There is also the inherent issue of patent and intellectual property rights, both in regard to protection of individual rights to incent the innovator, as well as those who wish to socialize the processes in order to promote widespread accessibility (Moilanen and Vadén 2012). To some, this is the scary edge of where individual property meets the benefitting of a community, and the question of whether concepts such as *crowdsourcing* and almost complete democratization of the industrial process is preferable to the twentieth century efficiencies of *Big O* organization and bureaucracy. Some researchers question the notion of a peer based production model as utopian, finding that Max Weber's bureaucracy system is better equipped to handle social problems than peer production, believing it is unsustainable (Kriess et al. 2011). Author Andrew Keen also expresses concerns with this peer production environment (mainly focused on the Internet rather than manufacturing) in his 2007 book, *The Cult of the Amateur*, noting that this model will destroy professionalism, leading to a shallower experience, not a deeper one. Public policy questions will inevitably be up for discussion as to whether a manufacturing strategy shall be set forth to promote or discourage peer production, as it is inevitable that it is not a matter of *if*, but rather *when* this type of technology platform is in place for widespread economic and market use.

There are other transition points occurring today that signal an end to mass production: there is the proliferation of *remanufacturing*, the practice of restoring used products for resale. The U.S. is the largest remanufacturer in the world, having grown 15 % between 2009 and 2011, is a $43 billion market, and supports 180,000 jobs (Wiens 2013), yet a niche market in contrast to first time manufacturing. A market principle that was put in place to enable mass production in the twentieth century was the model of *planned obsolescence* and even one time disposal products. Remanufacturing as a *transition point* signals an end to this era in resource use and waste, and a movement toward recycling and reuse to also include the blurring of a service; for example, a product of the future will be equipped with a sensor that will alert the buyer and perhaps even the producer that the product needs to be serviced, fixed, or even remanufactured, leading to the producer being responsible for the item itself, leading it to becoming more of a service for the consumer rather than a product.

Another manufacturing *transition point* that will continue over the next decade will be that of *reshoring*, or the bringing of manufacturing back from developed nations, like China and Mexico, and back into the U.S. and other developed economies. With new technologies continuing to emerge that possess lower capital expenditure costs and virtually no labor that outruns the rising labor costs in developing nations, it is becoming logistically wise to bring manufacturing back into home country economies. In 2001, oil was at $20 a barrel, and labor costs in China were less than a $1 an hour, making outsourcing of manufacturing somewhat of a *no brainer*. Today with China's wages close to $5 an hour, and oil prices anywhere from $50 to $100 a barrel, the move back to home countries makes more sense (Phillips 2014), especially on the backs of advanced manufacturing, even if oil prices continue to fall instead of rise. In a recent A.T. Kearney report, it was shown that reshoring at present "is not all that it's cracked up to be" given less of an impact coming back than is still being sent to low cost countries (Hagerty 2014), such as Vietnam where labor prices remain low. As technology becomes a greater part of the overall supply chain equation, even these lower labor prices will be trumped, and it will more efficient to return production back to the home country than a global model of mass production. With advancing technologies, and the prospect of resource limitations in a growing world of over seven billion people, will it one day make sense to produce all of a nation's iPods and Nike athletic shoes in its domestic market rather than in faraway sweat shops?

The Future of Manufacturing

After this transition point, the future of manufacturing that I will describe in this section will overtake the mass production model in about 10 years, approximately in 2025. If you believe this is a far-fetched idea, consider that the market valuation of many of today's peer based companies such as eBay ($67 billion) and Uber ($18 billion) are much larger than some of the conventional manufacturers of the past and present (Lehrer and Moylan 2014), and this trend will only continue. The intrinsic value of a peer based company, or even economy is different from that of a mass production based company or system in that the latter seeks growth through production and consumption on an infinite model, while the former blurs the line between products and services, and includes sharing over ownership. For example, while there is a twentieth century model to car ownership that identifies your car brand with your sense of worth, there is a growing twenty-first century model of an auto that treats it as a service, something necessary for use, but not to own. Therefore, transformations of technology will lead to changes in societal values that will lead to changes of a frictionless market; technology will be the enabler, not the driver.

Peer to peer or the 3D printing of products will increase production speed while reducing distribution costs. In contrast to mass production, 3D printing will lead to on the fly revisions and customizations, but these technologies in the short-term will require heavy capital investments that may lead to a manufacturing model of capital intensive manufacturers being the producers for the prosumers rather than home printing. 3D printing customization can lead to a variety of options, depending upon the involvement of the consumer/prosumer: one, there may be prosumers who find intrinsic enjoyment in the overall process (Moilanen and Vadén 2012), wish to become a member of a *crowdsourcing* effort to design a product, or may simply want to choose a templated or even standard product of the producer. Furthermore, this mode of peer production could even lead to an aspiration of community or *commons-based peer production*, as noted by Harvard professor Yochai Benkler that becomes shared within a distributed network (Moilanen and Vadén 2012). This could lead to a networked commune of *prosumers* who manufacturer for one another, separate from open market activities.

In the future of manufacturing additive manufacturing techniques will be able to embed one material into another, such as electronic monitoring into medicine, or any product that you can think about today; as Ray Kurzweil has noted, rather than smart devices that fit into our hands, it can be embedded into a drop of blood or anything else. In a subtractive manufacturing process, embedding components into another material is a time-consuming, costly and complex process; in 3D additive manufacturing, it will become a matter of cost effectively *printing* the product (Wadhwa 2012). Not only in the combination of materials and functional components, as well as the reduction of material reuse and therefore waste, but also in energy use as well; Jeffrey Brinker of the Sandia National Labs has modeled a self-assembly process to create glass in a low temperature manufacturing process, therefore reducing the mass production problem of *heat*, *beat*, and *treat manufacturing*.

The future applications in manufacturing are transformational beyond our current capacity to understand. While I believe that 3D printing will revolutionize manufacturing in the next ten years, replacing the mass production system, I do believe that, initially (perhaps for 20 years), the technology required will be prohibitively capital intensive, requiring a *production middleman* to mediate, or be a *friction*, prior to it becoming a pure peer to peer model. Today, 3D printers are primarily a novelty and a niche within the *open source* community more so than being embraced by conventional manufacturing platforms; of no surprise, 3D printing is primarily "a western thing", which could lead to a transitory divergence between large scale, today mass production, and small scale, future peer production (Moilanen and Vadén 2012). The greatest challenge of 3D printing will be, not in the development of digital design, or even layering of *digital slices* of design through a printer, but rather the development of complex designs in the embedding of various functions, such as electronics and nanomaterials. 3D printing is well on its way of designing and fulfilling lighter aircraft parts in order to reduce fuel costs (The Economist 2011), but this is relatively easy applications that require few, if any, material combinations. The big challenge will be when a 3D printer can design and create complex products, such as today's smartphone that presently requires 60 or so different metals and other materials.

Most likely, a solution of 3D printing will not be sufficient to achieve this level of product complexity. Today, complex manufacturing processes, such as the intricate assembly of a smartphone, requires robotics with a limited degree of capacity. However, in the future of engineering, these issues of micro-assembly could be resolved through the use of self-assembly (Nanowerk 2014). At a nano-scale, there could be ability to *program* physical and biological materials together and even change their shape and properties without human intervention. This manufacturing process is called self-assembly, or the spontaneous formation of ordered structured from smaller parts, taking advantage of the motion and nature of molecules (Tibits 2013). This process that would be enormously beneficial in the medicine and electronics fields and the assembly process can be controlled to make shapes and functions just by applying energy to it. Through the use of geometry and energy, the concept of design is effectively eliminated (as addressed in Chap. 3), leading to an emergence, not human design and then manufacturing. Interestingly, MIT researcher Skylar Tidbits categorized the current state assembly line as "humans with the intelligence and machines providing the energy", and in the future "machines and materials having the intelligence, with the humans just applying the energy" (Tibits 2013). With this, there is a complete paradigm shift in the manufacturing model, even beyond our present transformational concept of 3D printing.

Through this concept of molecular assembly, concepts such as creating materials with the strength of spider's silk now becomes possible, as was discussed in Chap. 4. In today's concept of 3D printing, software translates computer code and raw material into a physical object, but in molecular assembly, a genetic blueprint is used as computer code and then the DNA is *back calculated*, and then inserted into host bacterium to achieve the material (Krassenstein 2014). Think about the possibilities of manufacturing using a molecular manufacturing model: the manufacturing of human organs, sophisticated electronics, advanced food, and renewable good materials of all types. The key to this process will be manufacturing technology that will be able to effectively arrange atoms, building complex structures with atomically precise control (Drexler 2003). This concept of a *nanofactory*, as articulated by K. Eric Drexler of MIT, is of significant ethical concerns in regard to the negative consequences of such processes in the wrong hands; however in regard to less nefarious applications other than biology that would indisputably help product development and industry in general, the disruption to the economy from a mass produced at a nano, micro scale would be enormous.

Perhaps the manufacturing application of molecular manufacturing that veers slightly away from these perils is that of 4D printing, which is essentially the self-assembly of materials using a 3D printer paradigm. In order to assemble a more complex product than is possible through conventional 3D printing, but wishing to utilize this *do it yourself* technology, a product could be produced using the printer, and then could self-reconfigure later on in the process. This process could not only be used for the manufacturing of more complex products, but also enabling products to repair themselves in a process; a chair that can turn into a table or a water pipe that can heal itself (Campbell et al. 2014). This manufacturing process will likely be able to take greater advantage of the *material genome concept* of design than a conventional 3D printing process, enabling the future of peer manufacturing.

Tied to this concept of 4D printing is that of claytronics, or *programmable matter*; the ability of a product to transform itself, not in the manufacturing process, but while in use. With claytronics, matter can be transformed into any shape for any purpose; blank walls could grow doors or windows, with these manufactured items touching every aspect of our lives, including transportation and housing (Pelletier 2014). With the quality of nanocomposites improving in an accelerated manner, these applications could be in use by 2020.

2025: What Is Your Strategy?

In this new world of manufacturing, science and business should become a powerful, more collaborative force of the future. Science and technology will obliterate any frictions of the present; transaction cost economics and large organizations will be torn astray by these new market realities. To some extent, a movement to a peer production environment moves back in history to prior to the Industrial Revolution, and the individual craftsman's approach to manufacturing (Lehrer and Moylan 2014). Individuals will have access to software code, the definition of materials and composites in order to *design* something; it will all be open source, with the recipes out there for everything to partake as a prosumer. However, there is one limitation, at least in the next 10–20 years; the actual manufacturing of the product itself will likely have to be dispensed to a large capital intensive outfit with the sophisticated equipment capable of undertaking what has been articulated in this chapter. There will be a peer production *manufacturing divergence* between simple designed and constructed parts that can be produced at a person's own 3D home printer, and, let's say, someone's desire to design and build their own smartphone or automobile that requires a sophisticated layering and compositing of additive manufacturing and molecular assembly/engineering. From a distribution question that will be addressed in the next chapter, it's a question of whether a manufacturing and retailer will be specific to a certain function, like exists today, or whether one will have their autos and smartphones produced at the same 3D or 4D printing operation.

The future is already here, in many cases; 3D printing is being used to create plastic molds as a replacement to traditional braces to straighten teeth, and enhanced part design and replacement parts are being designed and developed for a variety of products such as snowboards to airplanes. As well, changes are already emerging across supply chain systems in regard to the creation of *digital production plants*, reducing design and inventory costs by up to 80 % (The Economist 2011). This will resonate throughout today's global supply chains, leading to more reshoring, less warehouse inventory, lower transportation costs, and the changing role of the consumer to prosumer in the process.

Despite the heavy emphasis on research for nations to develop the latest and greatest technologies, we know from experience that technology always proliferates and can neither be held back or away from others. Therefore, the greatest challenge will not be in the technology to enable manufacturing itself, but rather the policies and strategy put forth in place to enable it. In 1791, Alexander Hamilton scripted a manufacturing strategy that set the U.S. forward for almost 200 years to superpower status as a result. Definitely not as a coincidence, as is shown in Fig. 5.3, America's reduction in capital investment to a healthy manufacturing strategy has led to increasing output without a belief in it as a platform for the future. This should be of greatest concern to the American public and those of other developed nations.

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Chapter 6
Frictionless Markets: No Supply Chain Required

The Balance of Nature and Supply Chain Myth

The "balance of nature" view and its derivations assume that ecosystems, as integrated communities, maintain themselves in equilibrium if undisturbed by man (McGuire 2014). Many environmentalists subscribe to this theory, pointing to examples of the symbiosis that exists between plants and animals (photosynthesis), or nutrient cycles and no waste in an ecosystem, and expecting for industry to create similar systems. Often the discipline of the supply chain professional presents an equally beautiful, yet largely conceptual picture of an industrial supply chain: one of balance, harmony, structure, discipline and optimization. However, in reality there is no such thing as an ecosystem or a supply chain structure in a state of balance; rather both are varying degrees of organization across a collection of independently acting organisms or companies and workers that directly and indirectly affect one another, and emerge accordingly.

In his 2009 book, *The Balance of Nature*: *Ecology's Enduring Myth*, John Kricher suggests that no such thing as balance in an ecosystem exists, instead it is a collection of organisms that continually evolve, leading to changes in the system (Kricher 2009); balance if it exists at all is between entities. Perhaps from our view of the stability achieved in the twentieth century through large *Big O* organizations, we view balance in nature or business as the preferred state, when in fact, it is anything but the case. Over 99 % of all life to have lived on our planet is now extinct, and as well, most businesses and labor jobs no longer exist, which refutes this theory of balance. The twentieth century may have been a bit of an anomaly, as is discussed in Chap. 2, so any goal to either restore markets back to the 1950s state of high employment/high wages in the U.S. is not possible, nor is it possible to return to a pre-industrial era of slow growth and balance with nature due to a contrived *end of growth* model like some authors noted in this book have proposed. It is not possible to control an environment or an economy as some form of entity given its real definition is a function of micro level interaction, or self-organization amongst a variant of players, whether it is an organism, business, or workforce.

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The concept of supply chain management that will be discussed in this chapter was essentially invented in order to reduce the transactional cost of friction that has been discussed in this book that occurred in the twentieth century. As discussed in Chap. 2, these frictions driven by transactional costs were added in order to achieve massive economic scale and organization. Yet due to the accelerating nature of technology, our markets are becoming frictionless through self-organization and disintermediation without an appropriate structure in place. As a remedy, I discussed the need for a *no design* approach to products in our markets (Chap. 3), the use of *good materials* in our products rather than less bad ones (Chap. 4), and manufacturing methods that are additive, peer to peer, and of advanced technology in order to enable an optimal environmental and growth based system where the prosumer, not the *Big O* drives the process (Chap. 5). The advent of supply chain management in the twentieth century led to improvements, but largely through large organizations and structured systems; as a result, it as a discipline has led to tactical improvements in how companies and markets work, but of little strategic purpose. In this chapter, I will address how strategic changes in what we consider supply chain management to be will lead to a paradigm shift away from large corporations and supply chains into micro frictionless relationships.

The History of the Supply Chain

If you speak to a 100 professionals, educators, and students in the field of supply chain management, you will get a large variation in the definition within the discipline. I know this well because I am a supply chain professional across countries, have been on the boards of its largest and well-known professional organizations, have earned a Ph.D. in the discipline, and have taught its courses at the graduate school level. According to the Council of Supply Chain Management Professionals (CSCMP), perhaps the generally accepted expert organization in the field, supply chain management integrates supply and demand management within and across companies. Of course, this is an intentionally broad definition, and can span either across a supplier relationship, within a specific industry, or company, or even between a specific customer and its producer. In the post-Civil War era of the U.S., the transportation problem that existed in this continental nation commenced with a national railroad system, and the organization associated with structurally making it happen; starting in the 1870s, approximately 45,000 miles of track were laid, and then from 1871 to 1900, another 170,000 miles were added to the new national network (Library of Congress 2014). This new logistics network, along with improvements in technology and manufacturing techniques led to the need for the field of supply chain in the 1920s when the Ford Motor Company and its rivals in the auto industry began to produce using mass manufacturing; planning and coordination was required between the manufacturer and its suppliers, a distribution strategy was required to be created, and product inventory was to be determined. Functions such as procurement, finance, manufacturing, distribution, sales and marketing began to sprout in these large, growing companies, leading to questions such as planning, inventory management, logistics, and other functions that were previously foreign to an artisan manufacturer.

Prior to the 1950s, supply chain and logistics were largely related to military exercises, and for good reason; for the decade prior, the U.S. became the world power due to its ability to win the war through an industrial supply chain system that was unrivaled in history. As the story goes, a captured German soldier summarized in World War II how the Americans won the war; "I know how you defeated us. You piled up the supplies and then let them fall on us" (Gropman 1997). The Germans even had a name for this: materialschlact, or "matériel battle." There are many war historians who find that America's ability to use its industrial capacity through supply chain logistics was the primary reason for its ability to lead victory over the war. Yet after the war, the large industrial organization that were often spin-offs of previously war operations grew into silos without an understanding of cost tradeoffs, and levels of efficiency required for private practice (Ballou 2006).

In the new peacetime economy, an emphasis was undertaken to have demand drive supply rather than vice versa, leading to a focus on sales and marketing; distribution was included in the strategy, but more in terms of transaction channel activities rather than physical distribution; noted marketing professor Paul Converse addressed this issue in 1954 (Coverse 1954), stemming a focus on physical distribution in order to address rising transaction costs. At this time, more focus was undertaken in the efficiency of loading ships, railcars and trucks, as well as how logistics could be redefined within these different modes of transportation (Laseter and Oliver 2003). In 1959 was also the first noted outsourcing of production to Asian markets, with toy manufacturer Mattel creating factories in Japan and Taiwan to create Barbie dolls, the very symbol of the All American Girl!

Supply chain management may have taken roots in the 1950s, but it was the next three decades of the 1960s through 1980s when it became a respected field to rival others in business such as sales, marketing and finance. In the 1960s, logistics costs were very high in the U.S., accounting for 15 % of the total nation's gross national product (Heskett et al. 1973) that is approximately 11 % today (Federal Highway Administration 2005); in other nations in the 1960s/1970s, it was even higher, such as 26.5 % of sales in Japan (Kobayashi 1973), U.K. 16 % of sales (Murphy 1972), and China 24 % of GDP (Wang 2006). The recognition of these high costs was a sadly neglected area of American business (Drucker 1962). Now with a focus on these problems, manufacturing resource planning (MRP) strategies, improvements in manufacturing, and logistics, including reverse logistics and the use of third party logistics providers (3PLs) were implemented. In 1960, Gene Thomas of IBM defined the first method for *manufacturing resource planning* (MRP), including operational planning in units, financial planning and other methods within a closed loop supply chain system (Sanyal 2012). The Toyota method of "lean production" was built on flexibility and a reduction of inventory, making the Fordist approach seems outdated (Laseter and Oliver 2003). As a result of improved manufacturing techniques in Asia, improvements in ocean cargo transportation, lower labor rates in

Asia and escalating in the U.S., a significant global supply chain was built on outsourcing in the 1970s and 1980s.

It was in the 1990s and the 2000s when supply chain management really became a serious business practice area, driven through globalization, logistics containerization, the advent of supply chain planning, and the widespread practice of business process reengineering, led by Hammer and Champy's book, *Reengineering the Corporation*. As well, during this period, there was a breakdown of the rule that vertical integration always led to economies of scale, when in fact, sometimes disaggregation was becoming the better strategy (Stuckey and White 1993). This set forth more of a focus on cost reduction and innovation at the supplier end of the chain, rather than on the customer side (Laseter and Oliver 2003). As such, supply chain management migrated from a functional, often tactical role in the company to a strategic role that could lead to market penetration, as was the case by companies such as Wal-Mart and Dell Computer, which both used supply chain innovation to grow market share. Dell's postponement strategy in its upstream supply chain led to a negative 37 day cash conversion cycle, in comparison to positive 30–60 days for its competitors (Laseter and Oliver 2003), through process improvements it called "virtual integration". From a retail standpoint, Wal-Mart was undertaking a similar practice, achieving *just in time* inventory, and achieving efficiencies of scale across its supply network in order to offer the lowest prices possible.

The offshoring of manufacturing business continued, and through sophisticated process and technology through a communication revolution driven by the Internet, services, such as call centers were sent to India and China. Containerization, as noted by Marc Levinson's 2006 book *The Box*, plus sophisticated automation via accelerating technology led to a further splintering of linear, structured supply chain systems, often controlled by the original equipment manufacturer, such as Ford Motor Company. Today, the world has become, in the words of Thomas Friedman, a *flat marketplace*, a convergence made possible through accelerating technology and the supply chain system. This supply chain *convergence*, both in manufacturing and services, is also addressed frequently by Kishore Mahbubani, who noted in his 2013 book, *The Great Convergence*, that the benefits of rising prosperity amongst the world is an optimistic picture that will require patience and some sacrifice from the West, namely the U.S. (Mahbubani 2013). As an example of this global supply chain that is leading to a *flat world*, and convergence is Apple's iPhone that has parts that are sourced from all around the world, is assembled by Foxconn in China, which receives 2.5 % of the price, while Apple U.S. receives 66 % of the price of the iPhone (Laseter and Oliver 2003) without any benefit to U.S. labor. According to some policy analysts, by the year 2020, 80 % of the goods will be manufactured in a different country from where it is consumed versus 20 % in 2006 (Ballou 2006); in the frictionless market model that is illustrated in this book, I predict more, not less manufacturing and distribution will happen in the country where it is consumed.

For some, the emergence of the supply chain management practices has enabled a transformation away from the static, linear, vertically integrated structure of Fordism to an increasingly dynamic, often *virtually integrated*, global structure of convergence, or a *flat world* of global networks. However, many in the field, perhaps as much as 50 % per a Booz Allen global survey have expressed disappointment in the results achieved through supply chain management with respect to what was expected (Laseter and Oliver 2003). The goal of SCM was to incorporate system's thinking, both within the firm, as well as in a dynamic marketplace to link the changing nature of supply and demand. In its earlier decades after World War II, supply chain management was a very tactical exercise, focused on basic *blocking and tackling* exercises in planning and logistics. Through the popularity of business process reengineering in the 1990s, the convergence from globalization, and enabling technologies critical areas such as shipping, communications (Internet), and information technology, there was a hope that the supply chain would mature from *structured scaffolding* in place to enable *Big Os* working together in order to reduce transactional costs in a balanced marketplace, to an ability to connect the myriad of infinite actors in a market within the supply and demand function. Today's *supply chain innovations* are often restricted to tactical opportunities for retailers or suppliers to better sync on a front-end customer initiative, such as a promotional plan, rather than an aggregate transformation to shift within markets, or redefine them.

The Apocalpyse: The Obliteration of the Supply Chain

Today's supply chain systems are at their tipping points: unable to sustain the past of linear, *vertical integration* while unable to achieve the complexity required in a twenty-first century frictionless peer economy that is unstructured and self-organizing. Today, many of the largest companies continue to seek a formalized set of supplier and customer relationships that will become increasingly obsolete in a global + local = *glocal* dynamic business environment, led by accelerating technology. The question is, how will the supply chains of the future, or whatever its definition it is to become, be comfortable with a *glocal*, unstructured model of customization of peer to peer? If economies of scale disappear, and products become *prosumed*, so to speak, what happens to the *hub and spoke* model of supply chain that exists today? Will large supply chain structures be able to continually push a consumption based market model, to the point of excessive waste, or will individual nodes, or prosumers, drive supply and demand? Will this mean the end to *planned obsolescence* and a *throwaway society*, like today, where 1 billion one time use containers are used a day in the U.S., with over 60 % being sent to landfills? And finally, what will be the role of capital investment in technology versus an intended commitment to some sort of labor market as defined by a conventional workforce; will this even exist anymore? Will supply chains or its replacement drive a *multiplier effect* between technology and labor, as occurred in much of the twentieth century, or a *divider effect*, which is happening today? Such important questions will determine the future of markets in the twenty-first century.

To understand the path of the future, there is a clear trend line from the recent past from the transformation of supply chain as a critical business discipline, largely embodied by the unprecedented path of Wal-Mart. While this company is often vilified in the press, particularly related to labor rights and wages, there is no denying its success in unleashing technology and process to become the largest retailer in the world. From humble beginnings in 1950 as a *Walton's 5 & 10* in a small Arkansas town, Wal-Mart in 2013 had sales of $473 billion, returning dividends to shareholders of $12.8 billion, an amount larger than the market capitalization of most companies. Its trajectory towards growth was built upon developing information technology systems for inventory control in its distribution centers and warehouses to gain an edge on its competitors. Through technology and process, Wal-Mart introduced the concept of *vendor managed inventory* (*VMI*), which put the onus of responsibility for customer service and fulfillment on the supplier. In the 1980s, Wal-Mart continued to improve how it worked with manufacturing, working with suppliers directly instead of through distributors, and partnering together to create efficiencies; as such, the company changed the traditional relationship of the manufacturer holding sway over the supply chain, and now driving change through the retailer. From 1993 to 2001, Wal-Mart grew from $1 billion a week in sales to $1 billion every 36 h that was more attributed to supply chain management than customer service (University of San Francisco n.d.). Through best in class technologies and processes, Wal-Mart reduced its distribution costs to 1.7 % of sales in comparison to twice that of Kmart (3.5 %), and three times less than Sears (5 %) (Traub 2012). In this model, supply chain collaboration and efficiency led to transformations, leading to a balance of power change from the manufacturer to the retailer.

A model that transferred control of the supply chain from the manufacturer and distributor to the retailer would inevitably lead to the next change progression, especially given the proliferation of the Internet: transfer of control from the retailer to the consumer. While a Wal-Mart Super Center can offer a terrific combination of variety (150,000 distinct product offerings) and price (lowest prices on some, but not all products), it is only the best physical retailer on the planet. Moving forward, it would become the Internet that would overtake Wal-Mart; while Wal-Mart increased its product offerings, via online sales, to five million offerings in 2013 from two million the prior year, Amazon offered 230 million in comparison (Davis 2013)! Does this mean that Wal-Mart is competing against Target, or Amazon, and Amazon competing against them, or e-Bay? No, in reality, all of these aggregators in the future will compete against one, and yet a billion competitors, being you, the prosumer! In the twenty-first century, there will be less of an emphasis on a traditional supply chain, and more emphasis on a flat (as Thomas Friedman calls it), or frictionless market, in my terms.

Today, these mega retailers, such as Wal-Mart and Amazon, are migrating to a *omnichannel* distribution model that converges the physical and virtual for a perceived *best of both worlds*; selling products directly from one's website, the use of distribution centers to offer almost immediate product gratification, and using the Internet for consumers to shop and compare and then purchase at a physical storefront. While this convergence appears to be a perfect combination of physical and virtual, it is a logistical nightmare, as physical distribution centers were not designed to handle the kind of order structures that are prevalent in retail (Reinchart 2012), and it is only the largest of entities, such as Wal-Mart and Amazon that will even be close to enabling this sort of complexity. Growth in the multichannel or omnichannel model is putting significant pressure on retailers and their distribution centers; for example, on Christmas

Day, 2012, a record breaking 107 million consumers visited retail websites, a strain that distribution centers are not positioned to handle (Knowles 2013), yet retailers have no choice but to follow this model. The *Amazon Effect* in this *one stop shopping* of direct, wholesale and retail had led to a democratization of the supply chain in a manner of that it was not defined to be able to handle.

While many are applauding Amazon for redefining Wal-Mart's supply chain success at distribution, there is no question for me that these two giants are heading toward a lethal battle that will lead to the annihilation of the success models that each of them created. These two giants could spend the next decade fighting over who has the superior distribution model; Wal-Mart's forte of purchasing at mass economies of scale at the wholesale level and selling at low price retail, and Amazon aggregating virtually any manufacturers and services into its platform; a 10,000 physical store retailer versus an infinite virtual presence; one supplier that uses its distribution centers as retail outlets, while the other uses distribution centers to enable its virtual outlets. In the end, both will lead to the explosion of supply chain and the creation of something new: the frictionless market.

Who will be the winner in this epic battle? Perhaps both, or even neither; it will be the retailer who understands that neither of these models can succeed, and will start dismantling it rather than building upon it. When an insatiable customer demand model is fought for, *tooth and nail*, the number of product movements and touches (i.e., transaction costs) becomes out of focus, moving the model away from efficiency, yet competitors blindly speed over the cliff. The questions become increasingly maddening: should distribution centers be set up for direct fulfillment, should a backroom area of retail be used for even more warehousing than today, should there be alternative and more pick up points for online presences, should more distribution points be established through outsourcing (Atkins 2014), and so on. For sure, a pure retail definition will not survive as we are increasingly seen happen; shopping malls are shuttering, traditional mall anchors like Sears are showing its decline. Not only will this mean trouble for the retail outlets, but the brands themselves that will find it increasingly difficult to differentiate themselves (Lewis 2014). And with the decline of brands will mean the decline of malls and large traditional retailers, including supermarkets that focus on product brands to drive traffic. In the end, it becomes a maddening unsustainable model that will lead to the ultimate destruction of the twentieth century supply chain system, of which many of us have made our careers in taking part. In the rubble, we will become our own micro supply chain, looking for others to organize with, to emerge.

The Future: Emergence of Frictionless Markets

Where will this lead, and when? I will lay out a vision for the future in the next chapter, 2030: The Frictionless Market, but specifically to supply chain systems, the end is near in the next 5 years due to the overwhelming complexity and burden associated with the glide path of the present; I will discuss this for the remainder of this chapter. Returning back to the concept of the *balance of nature*, neither an ecosystem nor a supply chain is intended for balance, but rather emergence, a continual reorganization based upon the acting of players in the system. Today, our supply chains are literally ready to speed off the proverbial cliff as they organize around a distribution model that is neither sustainable from an economic or environmental standpoint. As consumers continue to demand greater variety at dirt prices, large retailers such as Wal-Mart, Amazon, and the large supermarkets will continue to chase these signal points until they ultimately collapse their supply chain systems, and that of their suppliers, under its own weight.

Tomorrow's consumer will not be today's consumer because the former will be both consumer and producer (prosumer), which will greatly change the supply chain landscape; this individual will consume differently, balancing consumption and production in a manner that doesn't exist today. In contrast, there is a disharmony within today's consumer, with some consuming beyond their wage, while others are in a small minority of wealth capture, leading to greater inequality. With so many individual nodes increasingly becoming in imbalance, the market, which is a make-up of all of the individual nodes, continues to become less healthy, in a *divider effect* environment. Further, this disunity between online and physical retailer presences leads to irrational behavior by companies, chasing increasingly sub-optimal consumer nodes. One more dysfunctional factor is the global supply chain network that further complicates and sub-optimizes the relationships between nodes, organizations, communities, and cultures; structured supply chains built upon cheap labor and emerging technology will dissolve, as a *glocal* network emerges individually between participating actors, rather than structured systems.

Traditional storefronts will disappear as well. Storefronts will be both physical and virtual, and be less brand focused; it will be as likely that a mall will consist of seasonal storefronts of individuals rather than permanent fixtures of brands in the future. The stores of the future will hinge as much on time as space (Gustafson 2014). Retailers are already experimenting with the concept of *virtual stores*, whereby one can browse through a physical location and interfacing with a smartphone. In China, the online grocery store Yihaodian and Tesco in Britain tested these concepts, with both increasing sales as a result (Gustafson 2014). In the future, features such as no need to check out and body scanning will be technology included at retail. Through the use of printed products, retail will change dramatically, impacting both the number of unique products that can be sold, but without carrying the level of inventory that is required today for variety; therefore, the problem that is being fought today between Amazon and Wal-Mart that will lead to the obliteration of the supply chain will be solved through these processes and technologies.

As well, this will dramatically change the nature of logistics, which today is largely addressed through a combination of capital (warehousing/distribution centers) and energy (transportation) costs. Today, often these costs and challenges are some of the greatest obstacles that companies face; there is increasing shortages in transportation drivers in the U.S., given health and safety requirements, and the volatile impact that energy costs and supply play on distribution. Yet the impact of digitization of manufacturing (3D and 4D printing) as a technology platform will lead to a disruption to the warehousing and transportation industry, just as it has impacted books, music, and movies (Brown 2014). Innovations in logistics such as logistics centers driven by software, electric vehicles, smart highways and self-driving or flying transportation will change the dynamic of the industry as well, unburdening these costs in comparison to how they exist today. Smart highways, fully automated navigational systems, and the layering of airspace will enable logistics to free up from ground surface and become safer and more efficient.

Most critical in this process is the transformation of market activity from being reliant upon *Big O* entities in order to plan, manage, and execute market activity. And yet there will be a significant, but different role for large entities in the future: one, to introduce and manage large capital investments to enable accelerating technology, and two, to aggregate or facilitate market activity, both roles that existing large entities like Wal-Mart and Amazon could transform themselves in the future. For example, while 3D printing and even more sophisticated concepts like 4D printing are on the horizon, leading us to believe they will be available for residential use in the near future, more sophisticated, advanced technologies will require a significant capital investment that will be prohibitive to individuals in the short-term. Therefore, Wal-Mart may become an investor in these enabling technologies and become a *3D Fulfillment Center* for prosumers in the future. If it continues on its existing path, Amazon may continue to be the leader in *market aggregation* or facilitation in the future; a platform for which prosumers can link in the future.

One last important implication to note for the future is one that is a critical concern of mine, especially related to my role as a supply chain professional in the beverage industry and related to my research role: the future of packaging waste in this new frictionless model, as defined by changes in the design, manufacturing, and distribution of products. The paradox of packaging today is that it is not only *big business*, being over a $800 billion global industry that continues to grow, its growth is largely predicated upon extensive waste, almost entirely based upon a one-time use model (Smithers Pira 2014). As I have found in my research, conventional solutions to the problem have increased the economic viability of its growth, but not environmental sustainability; thinner, stronger, lighter materials have reduced the use of materials, and even reduced logistics costs of lower fuel use, but has actually increased waste, particularly in the use of plastic. Biodegradable and other forms of green packaging have been more marketing than reality given these materials will often require expensive forms of disposal that are not cost justifiable, as was discussed in Chap. 3. Often, it is recycling that is promoted as the fix to these problems of packaging waste, but these human practices are simply an effort to make the problem *less worse* than *good*. While some opportunities seem promising, such as solvent based inks for printing on packaging, these are incremental rather than transformation changes.

Game changers in the future will become the vision of what has been discussed in the past: either 100 % recyclable, biodegradable, or no packaging at all. Future possibilities for 100 % recyclable packaging includes more use of aluminum, which is truly 100 % recyclable, and similar materials, perhaps designed by supercomputers that can be reused at a high yield rate like aluminum, which has a 89 % rate.

Biodegradable materials may truly be those that can be thrown into a landfill and degrade like a leaf in nature, a wrapper that includes bio material with seeds that can lead to being a *good product* with a positive effect on the environment, like Dr. Braungart notes, and even programmable materials that change its form after the product has been consumed. Finally, perhaps the *no packaging* mode is the most promising process and technology for the future since it requires nothing to waste; in Germany, Italy and Austria entrepreneurs have established the first packaging free supermarkets, with a wide array of 600 products (Nguyen 2014). Toothpaste is being developed as single chewable tablets without the tube, and Harvard professor David Edwards is developing packaging made out of gelatinous skin that can either be considered a *packaging-less*, or true biodegradable packaging. Such game changers will not only reduce waste to make the environment better (not *less worse*), but increase economic activity as well.

The last two chapters of this book will answer the most important questions in regard to this twenty-first century future of frictionless markets: one, what does it look like, and when will it happen is the first question; the second question is, if this is what is going to happen, what impact will it have on not just the economy and the environment, but an individual like yourself in the future. In the next chapter, Chap. 7, I will lay out the future of frictionless markets when it is in a mature state in 2030, and to conclude in Chap. 8, I will finished with the future macro and micro economic and environmental implications as a result.

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Chapter 7
2030: Frictionless Markets

2030: The New Market Structure

In the twentieth century, supply chains were relatively simple, as is shown in Fig. 7.1 below: the original equipment manufacturer, or OEM, was at the epicenter of the process, such as Ford and GM in the twentieth century. Production held sway over the process, and OEMs used their muscle both upstream and downstream of its process in order to achieve growth. This led to a model of unprecedented economic growth and prosperity for all, as the structured supply chain relationships were kept together by the frictions of transaction costs, and the lack of any substantive competitive overseas enabled U.S. companies to use their capital for higher wages more so than capital improvements, which enabled the *multipler effect*: workers were paid well that led to more consumption, and more consumption led to greater production.

In Fig. 7.1, the owner of information regarding the supply chain was the manufacturer, and the OEM used this information to its advantage. In many cases, the OEM *vertically integrated* (took control of more of the supply chain), taking even greater control of the information to make decisions. In most supply chains, the role of the retailer was to sell the products, as was provided to them from the distributors, as cheaply as possible. In the late twentieth century, Wal-Mart began to transform this position, as is shown in Fig. 7.2, through its use of information: instead of using information to effectively *control* the process, it used it to make the process more efficient. As the entity closest to the customer, Wal-Mart began to take the lead over the process, using its information and economies of scale in order to require greater efficiencies from the OEM, and created the concept of the *big box retailer* that effectively eliminated the need for a middleman distributor. Increasingly, it became the case that it was the transportation provider who was responsible for delivering the product from the OEM to the retailer, and the distributor, who played this middleman role, began to fade away.

In this model, Wal-Mart's limitation is having *only* 150,000 unique product offerings, which is insufficient when there is a world of product possibilities that

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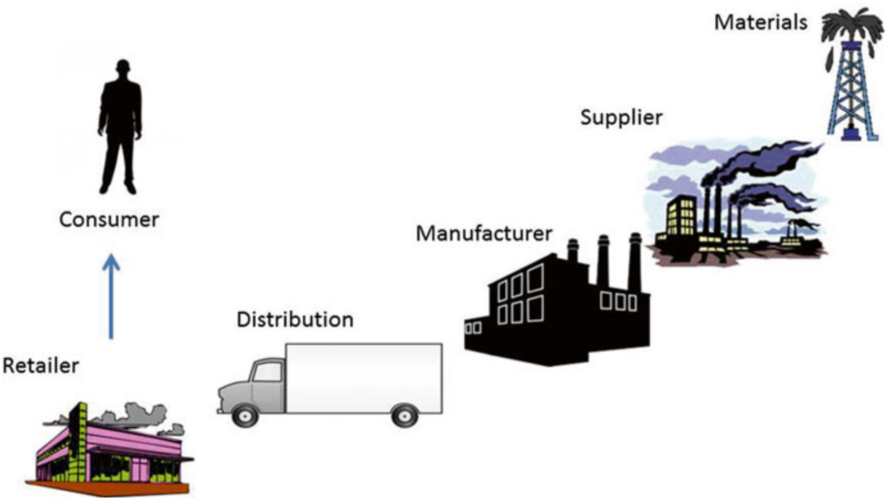

Fig. 7.1 Traditional nineteenth/twentieth century supply chain structure

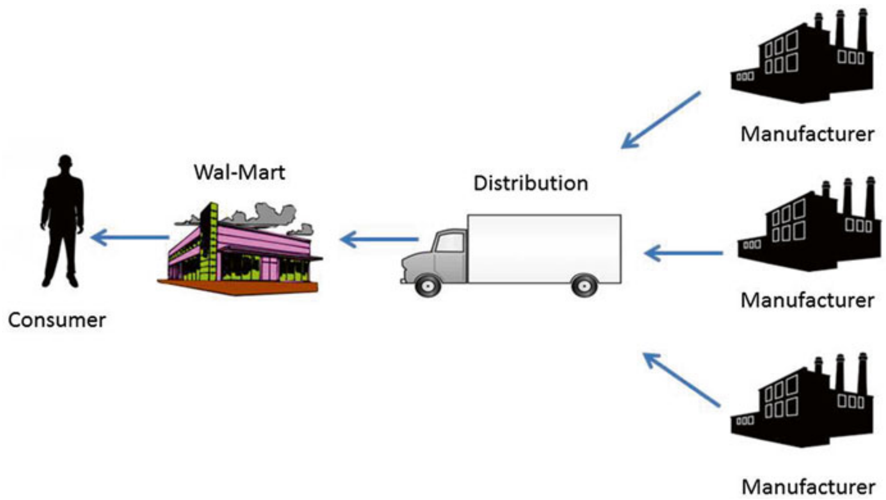

Fig. 7.2 "Wal-Marted" supply chain structure

can be delivered over the Internet that is near infinite. In the Amazon supply chain structure, the supply chain expands from 150,000 product offerings to 230 million through Amazon's *virtual supply chain model* with almost anyone as a manufacturer and distributor and Federal Express providing the logistics solution. Yet, this is not the end to the story because not only does a consumer want a virtually infinite array of product offerings at the lowest price, she wants it now! To address this challenge, Amazon has been *structuring* its virtually supply chain system through

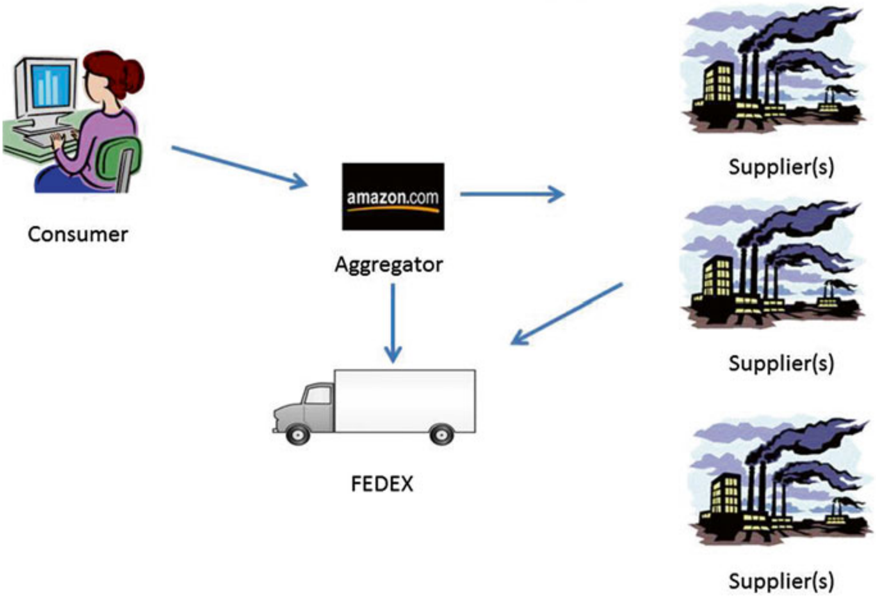

Fig. 7.3 "Amazoned" supply chain structure

bricks, while at the same time, Wal-Mart has been making its *bricks* more suitable for *clicks*. It is this convergence of the *bricks and clicks* that is leading to the obliteration of the supply chain that I discuss in the last chapter (Fig. 7.3).

Today, it is 2015, and for the next 5 years, large retailer presences like Wal-Mart and Amazon will extend this *omnichannel* model to create a lethal combination of a frictionless customer experience (leading to a reduction of transaction costs) with an increasing burden of fulfillment centers in order to offer faster fulfillment. While this model becomes an inevitable experience for the largest physical retailers, such as Wal-Mart, Target, Tesco, and Costsco, and the largest virtual retailers such as Amazon and eBay, its becomes a death knell for *smaller large* companies that cannot keep up in this transformation; in this five year period, we will see the end of physical retailers such as Sears and Radio Shack, and many of the smaller virtual retailers will simply fall under the fold of the large aggregators like Amazon.

At the same time this is happening, accelerating technology will continue to unfold in regard to the design process (Chap. 3), the creation of new materials (Chap. 4), manufacturing techniques, specifically 3D and even 4D printing (Chap. 5), and supply chain distribution (Chap. 6). In 2020, the opportunity will exist for large companies, not that are developing cutting edge technologies, but rather to develop process and business models for supply chains to distribute what technology can conceive and produce. New players will exploit the new possibilities from these accelerating technologies in a manner that *does good* for society, and not *less harm*; they will become twenty-first century titans, in the legacy of John D. Rockefeller, Henry Ford, Alfred P. Sloan, Bill Coors, Howard Schutz, Bill Gates, Sam Walton, Steve Jobs, and Jeff Bezos were able to do so.

It will be the visionaries in 2020 who will build the future for 2030, not the enablers of technology. While it is possible that one or a few of the large manufacturers and retailers of today are able to make this transition, based upon history, it is rather unlikely, as they are most focused on serving short-term markets. Technology will accelerate so rapidly in the future that only the best innovations of business process will be able to conceptualize in the year 2020 what things will look like in 2030. As well, it will be the innovators who will understand that the role of the leaders of the markets will continue to evolve: in the late nineteenth and early twentieth centuries, captains of industry like John D. Rockefeller and Henry Ford saw their role as the controllers of the markets. In the late twentieth century, the leaders of Wal-Mart saw it as their role to drive market activity through facilitators of supply chain collaboration and efficiency. Shortly thereafter, Jeff Bezos viewed market leadership as a *virtual aggregator* of market activity. In the future for these twenty-first century frictionless markets, the role of the visionary will be to continue the path of Amazon and double down upon it: for the entire supply chain process to *be peer to peer* in the creation and enablement of the prosumer.

This is the concept of the twenty-first century *frictionless market*; for the remainder of this chapter, I will provide real life examples of the future in how it will become reality in the next 15 years.

2030: 3D Mart

In 2016 or 2017, the printed product business will become available in niche areas, such as a 3D printer in a dental office for the creation of braces, medical equipment, auto parts stores for replacement parts, niche toy and hobby stores. Most of its initial uses will be focused on the *DIY* (do it yourself) crowd that enjoys digital design as a niche area of enjoyment for its products. Today, there are 3D printers available for the DIY crowd, and this will continue into the future, but the real opportunity will be for prosumers to design rather than manufacturers, leaving the high capital investment for rapidly evolving equipment to others.

A few years later, perhaps 2017 or 2018, the printed product business will extend beyond the niche DIY crowd into the mainstream, but not through the average person buying a device, which would be prohibitively expensive, or relatively unsophisticated and of little functional use. In the year 2017, one of the large big box retailers will kick off the first use of an industrial scale 3D printer for consumer use. This device will be at the front of the store, and will start off as a novelty to bring consumers into the retailer. Perhaps the function of this first 3D printer will be for the consumer to pay $10 to design their own product at home (on 3Dmart.abc), and then to come to the store for *product fulfillment*, using the person's own materials, such as used PET bottles. The retailer will find another way of attracting the consumer to the store through this novelty, and be considered as environmental for enabling the consumer to use trash to create products design by the individual!

To further achieve the *omnichannel* concept, the 3D Mart begins to develop customized product offerings based upon a base design template. For example, simple one or two material type products can begin to be either fully printed or customized at the big box retailer. Examples of this are athletic shoes, IKEA type furniture, seasonals (like holiday decorations, perhaps designed for your family), auto parts, tools, party supplies, and kitchenware. In its first year, 3D Mart prints only 500 of its 150,000 product offerings, but the wheels are in motion. Instead of it being one 3D printer for all functions, 3D Mart transforms its supply chain through manufacturers offering machines in order to produce its products on site. For example *Under Armour* provides a 3D printer for each 3D mart store; first as a niche promotional opportunity for individuals to design their own shoes, but the end state goal is for all of its shoes to be designed by the consumer, *in situ*, and then fulfilled directly at the 3D Mart.

Upon the rollout of branded 3D printers to replace brands in *big box* retailers, the virtual retailers strike back with their first entry into printed product retailing, starting in 2021. In contrast to the *big box* retailers, who are providing printed product offerings tied to the brand offering relationship that already exist, the virtual stores focus on brands directly from 3D manufacturers and prosumers who purchase 3D printers in order to focus on niche product offerings. Eventually, these virtual retailers realize that they do not possess the same relationships with the brands as do the *big box* retailers and the smaller 3D manufacturers and prosumers do not possess 3D printers with sophisticated enough technology to compete. In order to compete, the virtual retailers realize they need *last mile* fulfillment centers with sophisticated 3D printers in order to be able to aggregate the small non-brand designers. By 2025, the largest virtual retailer 3D.abc, builds a sophisticated network of 3D printers across markets, offering prosumers the opportunity to compete against the large brands to offer practically anything that they wish to design and market. In return, 3D.abc will be the *last mile fulfillment center* (*LMFC*) to where the consumer will pick up his product. In 2026, 3D.abc has also provided an almost infinite list of *material genomes* in its design site for *prosumers* to use in order to design not just new designs, but completely new products as well.

In 2027, *big box* retailers such as 3D Mart realize that the concept of brands are in trouble, as the prosumers are able to sell similar quality or better customized products to consumers at lower prices, fulfilled at the LMFCs. By this year, roughly half of its supercenter space is allocated to branded 3D printers *versus* branded products, conventionally retailed. While 3D Mart is moving in the right direction in regard to its mix of products traditionally manufactured and distributed and those designed *in situ* and produced on site, they are handcuffed by the company branded 3D machines *versus* the equally sophisticated, but more flexible and less expensive general purpose machines at the 3D.abc *last mile fulfillment centers* (LMFC). In direct response, 3D Mart begins to allow non-branded 3D printers to be used in its *last mile fulfillment centers* in direct competition to the branded machines. As well, both 3D Mart and 3D.abc not only are in direct competition to aggregate the best designs by either prosumers or branded companies; they also offer incentives to them to design completely new products unknown before. This leads to contention between 3D Mart and product branded companies.

By 2030, brands exist, but are more niche than ever, as loyalty has been neutralized in favor of rapid change and constant transformation. Prosumers are peer to peer and constantly competing against one another for the consumer's attention or the consumer themselves. The best prosumers sign *last mile fulfillment center* deals with the provider who has the best technology, the most affordable pricing, and even the newest materials; in order to achieve the latter, the *LMFCs* must also have arrangements with materials designers (run by supercomputers) or conduct its own research. New materials are developed, and able to be composited with existing materials will be a competitive advantage that the best prosumers will wish to leverage. In 2030, materials have increasing sophistication in order to enable the most complex product designs possible, including embedded electronics technologies. Programmable matter and 4D printing also begins to emerge.

It is not just the design, materials, and manufacturing that is the focus area of competitors such as 3D Mart and 3D.abc, but also the user shopping experience. The prosumer's own technology can interface with the operation when he is at home, in the store, or anywhere else. The store experience will dramatically change as well, with virtual reality and body scanning, among other technologies, coming into play. As well, the prosumer will have the ability to be both a producer and consumer, being able to sell her design/product at the retailer while at the same time being a consumer as well, in a cashless manner.

2030: Printed Food and Drink Markets

If you thought frictionless markets would not extend to what you eat and drink, and how you will do it in the future, you're wrong: 3D printers are already on the horizon in this sector as well. World's largest pasta manufacturer Barilla is already deploying 3D food printers to deploy in restaurants across Europe to enable customers to personalize their pasta. The greatest issue at the onset is both cost and speed, with both expecting to improve exponentially in the near term future. As well as pasta, there already are commercial grade 3D printers for candy and cakes; the Chefjet 3D printer can create candy and cakes from powdered materials and water for about $10,000, which means it's only viable for commercial operations (Stenovec 2014). For now, there are many other products on the horizon; Oreo cookies, 3D pizzas, pancakes and Nutella; Fig. 7.4 shows an example of the design of a 3D food printer.

For the most part, the concept of customizable soft drinks is already at a retailer or restaurant near you; Coca-Cola has dispensers at restaurants that enable a customer to create his own beverage using flavorings and standard soft drinks, and Pepsi has rolled out *Pepsi Spire* that will do the same. For home use, SodaStream offers the consumer an opportunity to create customized soda, and soon it will have competitors such as *Keurig Cold*, and maybe *Pepsi Spire*. These technologies will eventually migrate into 3D printing and utilize *the Internet of Things* in order to transform soft drink use. While it will not be as easy, or even possible, to *print* adult fermented beverages, such as beer, wine and spirits, it does not mean that the trend toward frictionless markets is not happening today. In the beer industry in the U.S.,

Fig. 7.4 Example of 3D printer design

Fig. 7.5 A nano-brewhouse

there are the large breweries that produce tens of millions of barrels a year, and then there are the *microbreweries* that can produce in upwards to a half a million barrels a year. The new trend is toward the *nanobreweries*, which is a growing trend for operators or even hobbyists who produce less than 500 barrels a year; peer to peer is revolutionizing this industry, and will do so for all food and drink! (Fig. 7.5).

The trend toward nano-products (beers, wines, spirits, sodas, meats) will continue in the next decade, as will the uses for 3D printing at retailers and restaurants. Yet similar to the 3D Mart case of above, manufacturers and retailers will desire to take advantage of the *DIY revolution*, as well as the special properties that will become marketable in relation to their products and operations. By the year 2020, 3D printed food and drink markets will begin to emerge, similar to the transformation of non-consumables; a large *big box* retailer will offer a novelty application, perhaps co-sponsored with a food manufacturer, such as Barilla, to offer customized product at the retailer and restaurant. Over time, this will lead to branded partnerships with large manufacturers, such as Coke, Pepsi, Frito-Lay, Kraft, and others, and also lead to store specialty products, such as pre-made meals. In the early twenty-first century, one of the fastest growing small businesses was the *easy meal preparation* outlets where customers would go and make a month's worth of meals with friends while having a glass or wine (Gill 2008). This DIY meal prep trend has fallen, with many of the franchises going out of business, largely due to the proliferation of specialty prepared meals at the large retail outlet. In the next 5 years or so, consumers will be able to *design* their own *home cooked meals* online, and then send the recipe to one of these large retail outlets that will *print* the meal for them to be picked up at an agreed time.

By 2025, not only will there be *printed* food and drink in traditional restaurants and supermarkets, but there will be outlets that solely specialize in it. First, there will be printed candy and ice cream shops and bakeries, and then it will escalate into restaurants and supermarkets. By the year 2030, a disintermediation will occur in food and drink, not just in the traditional restaurants and supermarkets, but also between *eating out versus taking home*; massive *printed food* outlets will exist for either buying groceries or for the dining out experience. The outlet will also include a variety of rooms that can be transformed to one's requirements: a family style dinner room, nightclub venue, sports bar, fancy restaurant, and *etcetera*. A consumer will be able to rent a room for a gathering, or eat/drink at a themed setting that can change based upon a season, or for any reason. As well, space will not be restricted to brand themed restaurants and bars, such as *Chili's*, *Joe's Pub*, and *Subway*, but can be *prosumed* as well; one night, you can visit the *printed food outlet* as a customer to a fancy restaurant with your wife, and the next night, you can host a meal that you *design* under a pizza restaurant theme for your kid's soccer team. As well, the prosumer can decide to be a restaurateur for a month or whatever time period, based upon one's desire for how to earn a living. Everything becomes frictionless.

The economic and environmental benefits of a *printed food outlet* by 2030 become a significant benefit to society. One, there is a reduction in waste, both in food and packaging as a function of this model. Today, 40 % of all food produced in the U.S. is never eaten, largely due to its planned mass production approach. In the future, if all food and drink are *made on demand*, food waste should be dramatically reduced. As well, in this model, there will be much less of a need for packaging to protect the food, therefore, reducing landfilling. As a result of a reduction of food waste in the U.S., perhaps from 40 % to maybe 5-10 %, the balance of what is grown and raised can be used to meet the needs of today's underfed, both in the U.S. and other nations.

2030: Virtual Service Mart

Beyond a transformation from planned, mass produced products with inventories and global transportation networks to a printed model of *in situ*, *DIY* design, and no inventory or transportation issues, there will be a migration from product ownership to a model of products and services fusing; today, more individuals are preferring to rent rather than own something, such as a car, motorcycle, or bicycle, or even using their homes as hotel rooms for outside visitors. This peer based economy considers a vehicle to be less a function of a physical status symbol and more of a service to get from one place to another. Likewise, in the future, more products of ownership may be viewed as services, with an intermediary in place to broker the borrower and lender, or perhaps even a partnership arrangement of multiple owners.

Not only in the brokering of products as services, but services themselves as well. In a frictionless peer to peer economy, the brokering and bartering of services can be handled through a trusted intermediary; cashless economic activity will be conducted through Person A mowing Person B's lawn, while Person B cleans Person C's house, and Person C changes the oil in Person A's car. It doesn't even have to be represented as simple as this; in some cases, the individual can be a prosumer, undertaking and receiving services, while in other cases, the individual can be a discrete service provider or consumer and total strangers. The future of a Service Mart to facilitate services through products, or just the service itself will lead to a frictionless peer to peer economy without the pressures of earning a living through a labor market with a downward pressure to wages.

2030: University of P2P and Meeting Plexes

The College and University system in many countries, including the U.S., is heading for financial calamity; in the U.S., the average debt leaving school is $27,000, and there's a 17 % default rate on student loans, which is rising (Karabell 2013). In a labor market where unemployment may be falling to around 5 %, but wages are falling as well, increasing college tuition costs is just not sustainable. The answer to this problem for a growing number of students, particularly non-traditional ones, is an Online University that has lower costs, similar to the disintermediation of other services, such as Travel Agencies and Insurance Agents of the past. As is shown in Fig. 7.6, online enrollment rates as a percentage of the total continues to rise, soon to reach 50 % of the total market. Not only due to lower costs, but also greater acceptance due to accreditation and superior technology platform capabilities, this model of disintermediation is already moving forward away from the traditional model.

The primary problem that the online education model faces today is one of credibility; there is a perception that a traditional program offers more prestige and capability, largely as a function of the academicians who participate at traditional universities, as well as the research platform where this exists. To mitigate this problem, the online university needs to focus more on research as a function of its

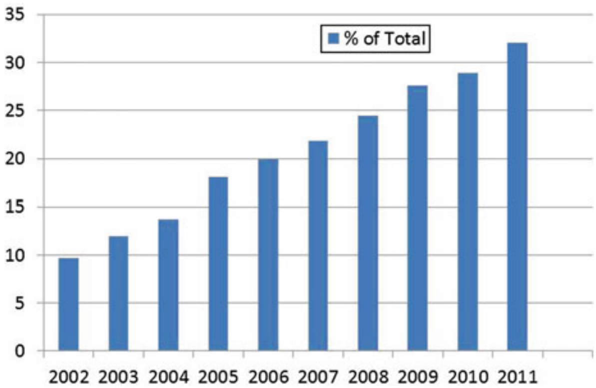

Fig. 7.6 Online enrollment rates (*Source*: insidehighered.com)

service offering as it does instruction. By 2017, some of the best non-profit, fully accredited online universities will begin to develop technology platforms, not just for instruction, but for research as well. With top notch research and development platforms in place due to superior technology fulfillment, these online universities will begin to recruit some of the top professors and researchers, improving the credibility worthiness of its programs. As well, through strong researchers arrives research funding and grants, leading to opportunities for students to build their future careers.

By 2020, online universities will begin to overtake traditional universities due to their superior technology and now talents through research. As a function of doing so, they will begin to transform the entire research grant process, making it more efficient as well; today, over 50 % of research grant funding can go to administrative costs rather than research, providing a poor return on investment to public funding sources and non-profit foundations. Through accomplished researchers taking part in online university instruction and research, and offering top notch research at lower administration costs, the online university model will grow in the future. However, even with greater capability and research programs in place, there is something missing in these programs: the face to face personal experience. To address this need and others in society that requires meeting places, in the future, there will be physical *meeting plexes* to serve the needs of a virtual world. These facilities will be multi-purpose to support a variety of functions of different group sizes and purposes: these multi-purpose rooms will be able to support physical classrooms for the schools and universities of a specific region, presentations for associations, or even a virtual author, prosumer moviemakers, special events, and *etcetera*.

In 2025, the online university has overtaken the traditional university in capability and scale, leading to these traditional universities of the past moving to niche purposes. However, online universities will be faced with a new threat: the University of P2P. Rather than a specific university with a specific organizational structure, higher education will truly become frictionless, peer to peer services, with prosumer professors being accredited to teach a certain course (rather than the university), and then being on his or her own rather than working for a university. In this model, the U of P2P is much like Amazon, or 3D Mart in being an aggregator, and the facilitator to ensure the quality level of the service is to the level expected by the consumer.

2030: Virtual Physical Communities (and *Vice Versa*)

Beyond frictionless supply chains and markets, there will be frictionless communities as well, some physical and virtual. A *virtual physical community* is a community that can span across the world that centers around a specific function or interest; for example, a chain of *print bakeries* could form an alliance *via* a *virtual physical network* to share recipes, or even collaborate on cake making to print at each of their locations. Instead of an Italian styled cake being made by someone in the U.S., it could actually be designed in Italy and printed in the U.S., therefore being an authentic product! The opportunities are endless in these self-organized clustered communities, offering *glocalization* of products and services. Beyond products, there are services opportunities as well, such as very specific medical specialists participating on a treatment or even surgery as they live on different continents. In contrast, a *physical virtual community* is a physical setting housed for the virtual world, such as to enable a virtual university or club to engage in a face to face setting; the meeting plex is an example of this.

Figure 7.7 represents the frictionless market model of the twenty-first century. While there will still remain conventional *Big O* bureaucratic companies in business

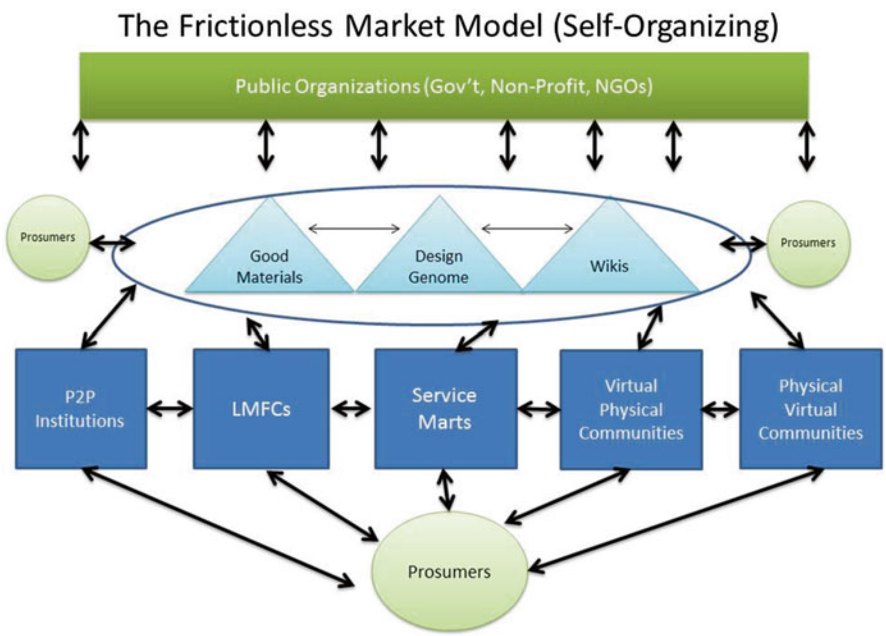

Fig. 7.7 Frictionless market model

in the future and in non-profit, and public organizations, the majority of economic and market activity will be based upon these frictionless markets of the future. As is generally illustrated in Fig. 7.7, the market becomes a self-organizing and emergent complex adaptive system, enabling the prosumer to drive economic activity in a peer to peer model.

It is my belief that this new system that replaces the conventional, fixed, linear supply chain structure of the past will address the economic and environmental problems of today; in the final chapter of this book, I will articulate how this can happen by 2030, changing the nature of markets and our *labor problem*.

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Chapter 8
Economic Possibilities for My (Not Keynes') Grandchildren

Introduction

In the year 2030, my oldest daughter will be 29, and my youngest daughter will be 26; it will be their economy and markets, not mine. Today, it is the youth, not a middle aged man like myself, who will be most affected by accelerating technology that leads to economic growth without a corresponding benefit to the worker. In January of 2015, the U.S. unemployment rate was announced at 5.6 %, with 2014 being the best year of job creation since 1999. However, underemployment is still almost double unemployment at 11.2 %, while the participation rate in the labor force was a 37 year low of 62.7 %, and real wages actually declined by 5 cents an hour. This is a clear picture of what has been discussed in this book: economic growth is happening without the labor force due to accelerating technology and its use. French economist Thomas Picketty correctly notes the statistics in his book *Capital in the Twenty First Century*, that both the wealth gap and income inequality have been steadily rising since the 1970s, but it is not due to the natural tendencies of a free market system, as he implies; rather, it is due to an imbalance, or unnecessary frictions in the existing supply chain system (Piketty and Goldhammer 2014).

For the remainder of this chapter, I will present the five major reasons as to why a frictionless market system will fix these imbalances in our present day system.

Reason #1: The Prosumer: Self-organizer of Supply and Demand

French economist Thomas Piketty is labeled "a modern Marx" by *The Economist* due to his perspective that rising income inequality must be countered with a tax redistribution system since the wealthy own such a large percentage of the capital. Of course, Piketty is correct about rising income inequality, but impractical in proposing a Big O government solution that will penalize the capital investors right at

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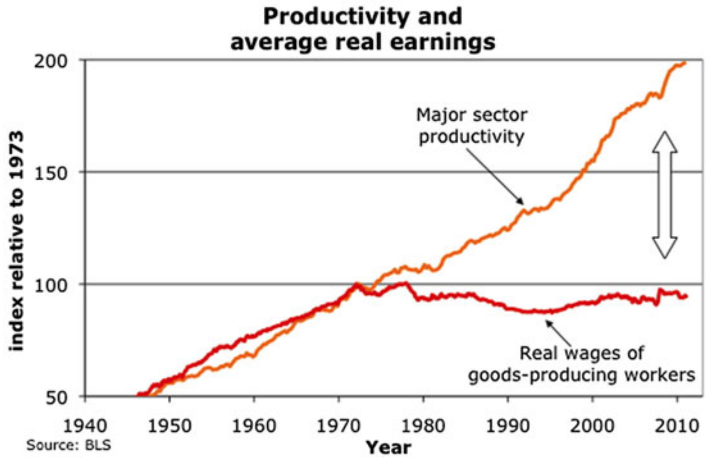

Fig. 8.1 Average worker pay to productivity (*Source*: outsidethebeltway.com)

the time when we need them to invest to bring forth this new peer to peer technology driven model. A frictionless market model will become the best of all worlds; no disincentive to the capital owners, including offering them an opportunity to thrive in the capital intensive aspects of frictionless markets such as the *last mile distribution centers* (*LMDCs*), but also the democratization of all aspects of the supply chain structure due to accelerating technology. Prosumers will be able to offer their services in product design, knowledge design (wikis), material creation, manufacturing (including DIY on their own separate from the LMDCs), distribution and sales and marketing. As well, prosumers will be able to offer their services to each other on a peer to peer basis, without the encumbrances of *Big O* organizations. Therefore, capital owners will be able to win, but not as imbalanced as today, and capitalism, not socialism, will balance the playing field.

Why will a self-organizing prosumer be better for a twenty-first century economy than today's conventional worker? Of course, this conversation must begin with what's happening to the worker of today; as is shown in Fig. 8.1, there is a growing gap between average worker pay and worker pay tied to productivity rates. Why are there differences between the current labor rate and a labor rate adjusted as a function of productivity? It appears as if the productivity is correlated to the benefits from accelerating technology while the labor that remains is in the words of anthropologist David Graeber to be “bullshit jobs”.

In the economic model of the nineteenth and twentieth centuries, as shown above, there is an inevitable divergence between the owners of capital and the labor of the workers; Marx himself warned that eventually, there will be the owners of capital, and everyone else who must work as slaves to these capital owners. This is an obvious conclusion and end result, since capital is used to expand growth through technological innovation, while at the same time, labor becomes increasingly less *value add*. By transforming to a peer to peer model, the *value add* of labor is brought back into the equation, while at the same time; the technology is commoditized. It is a reversal of roles between labor and capital: in the twentieth century, the former is marginalized while the latter proliferates, while in the twenty-first century, technological change reaches a singularity, making capital marginalized and labor proliferated. In this new model, there is a *multipler effect*, not between production and consumption, but rather prosumer to prosumer; it is not a demand or supply driven economy, but rather a peer driven one. It is prosumer self-organization, not accelerating technology that drives growth.

In contrast to John Maynard Keynes *Leisure Economy*, or others that profess *The End to Work*, such as Jeremy Rifkin's 1996 book that essentially proposes *Big O* experiments, my frictionless market model is a capitalist approach, migrating to one driven by a peer to peer model. The nature of humans, as is the case in the nature of life, is to self-organize, advance, to compete, rather than one of equality, moderation, or even punishment. Today's capitalist model prevents competition and advancement, leading to some policymakers to promote an extreme response; instead, the capitalist model needs to be transformed, not replaced, in order to take advantage of technology that is close to reaching a singularity of sorts.

Reason #2: Multiplier Effect Between Economy and Environment

Reason #1 finds that an economic *multiplier effect* is created through a frictionless market structure due to the *value addedness* within a peer to peer relationship through accelerating technology. With technology as the commodity, it gives an opportunity for labor to become valued, but not as a function of an organizational structure managed by capital, but rather labor as an entity by itself. Capital is involved in the process to invest in technology, but not to provide control over labor.

Author Richard Heinberg, who wrote the book, *The End of Growth*, contends that "economic growth as we have known it is over and done with" due to a variety of reasons, including the "depletion of natural resources and the proliferation of environmental impact" (Heinberg 2010). Admittedly, there are a myriad of examples of how our environment won't be salvaged if economics continue as it exists today. Figure 8.2 provides the most telling tale of statistics that I have seen in this debate: while those who deny the effect of manmade industrial activities on the environment have correctly articulated that the Earth's climate is in a constant state of change, it is the pace of change, not the fact that change is occurring that is indication of man's devastating impact on the environment. In rapid climate change, living organisms must either adapt or relocate in order to survive, but when the pace of change is too quick, this becomes impossible, leading to extinction. As a result of the speed of change, Man is not only irreversibly impacting the existence of many living species; he is also impacting his own long-term future because, while we are extremely adaptive to change as specie, we are not equipped to a rapid pace of environmental change.

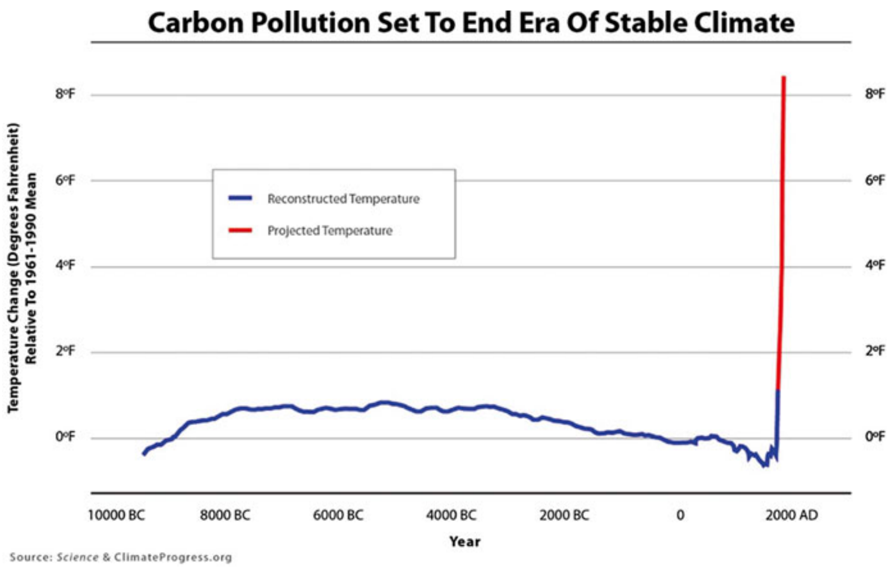

Fig. 8.2 Climate change pace in human time (*Source*: Thinkprogress.org)

In the model of conventional thinking, the issue is being addressed as one or the other: either we decrease our industrial activities that reduce economic growth, or we continue to degrade the environment, perhaps to our own extinction. In this model, there is a divider effect between the economy and the environment, with the impacts of each having a corresponding adverse impact on the other. In a frictionless market model of peer to peer, this does not necessarily have to be the case for the following reasons: one, products can follow a *no design* model, like nature, seeking to optimize conditions for both the economy and environment in order to achieve a *good material* design. In this new model, a *good material* is not just one that does less harm to the environment, but rather is additive to its ecological state. In contrast to the invention and production of plastic, which is harmful to the environment, but good for the economy, new materials can be created by supercomputers that positively impacts both.

In this new model, additive manufacturing is used in order to reduce waste in the production process. As well, the environmentally damaging mode of *heat*, *beat*, and *treat* that occurs today in the conventional, subtractive manufacturing process will be replaced with a low temperature additive process in the new peer to peer frictionless market model. From a distribution standpoint, the impact of economic growth to the environment will be negated because almost everything will be produced in the same geographical setting where it is consumed, and waste will be reduced. Products will no longer be almost entirely produced for ownership, but will increasingly become a service, allowing users to share it in order to reduce resource use. Finally, end of life issues leading to environmental catastrophes, such as poisoning our ecosystems with hazardous waste will be eliminated; with businesses have a requirement to product materials and products only that are 100 % reusable and biodegradable, and less need for packaging.

In this model, a *multiplier effect* will occur between the economy and environment, with each being used to improve the other; for example, a material developed that has biodegradable properties will increase economic activity when regulations require a manufacturer to use it rather than one that does not. As well, a new consumer food product that does not have packaging due to its distribution at the 3D Mart, or possesses either edible or biodegradable packaging that can be thrown into one's house garden will enable this *multiplier effect* as well. In this model, an environmentalist can become a prosumer, offering her services or products for economic growth. As well, large manufacturers, such as the 3D Mart, can proudly state their role in assisting the environment while making a profit. Carbon emissions will be reduced in this model, due to lower logistics costs in transportation, in manufacturing production, a *glocalized* economy, and even additive manufacturing using less energy.

As soon as possible, both sides of the argument (environmentalists and economists) must come to the conclusion that our best bet is not a *win-lose game*, but rather, a model of progress, evolution, and systems thinking; anything else would be against our human nature, and that of evolution!

Reason #3: *Small P* Centric Economy, Not *Big O* Structures

This will be a huge paradigm shift in thinking; whether it's through public institutions such as governments, or private ones such as corporations, individuals have become over reliant upon organizations to provide stability and growth within societies. Max Weber noted that the bureaucratic coordination of activities is the mark of a modern era because they are designed along rational principles. While this notion was certainly true in the early twentieth century, one hundred years have passed, leading to a new requirement of organizational structure in the twenty-first century: that of *little or no organizational structure*. In an economy and society that is evolving through exponential technological change, there is little need for the bureaucratic rules of the past; having individuals work through organizations as opposed to self-organizing in peer to peer is no longer rational, but largely irrational. Today, individuals are facing the prospect of *bullshit jobs* due to the use of technology within a large private or public organization that requires less value from labor. This equation of *Big O* and exponential technology is doomed for failure by definition; a continuation of this model is irrational in itself.

In contrast, a *Small P* (prosumer, or peer to peer) model enables the technology to promote labor value rather than to dispel the concept; peers are able to connect to peers in a frictionless market model, offering value to one another without the constraints of organizations. Think of this as is nature: there is not a large organizational entity that controls an ecosystem, but rather, it's an almost endless string of peer to peer self-organizing, emergent activities of nodes that interact that leads to progress. In the twenty-first century, there does not appear to be a sound reason for why our activities cannot exist in this manner. There will no doubt be naysayers who contend that our economy will break down without the large structures in place, such as increasingly large and few corporations with a larger percentage of market share, and/or large governmental organizations in order to control activity through regulation and ensure trade flow. To those who believe that we need the *Big Os* for our twenty-first century economy, I recommend for them to read Max Weber's 1922 book, *Economy and Society*; upon reading this work, most of us will understand that what was necessary almost 100 years ago is stunting our progress today. There is no reason to fear our ability to achieve rational economic growth through ourselves.

Reason #4: Global Market Balance Through Glocal

The irony in today's global marketplace is that while technology continues to make the world smaller, it inevitably leads to the world wanting to become larger in the end. This is due to the best interests of a multinational corporation not often doing what's best for a national labor market that can lose higher paying employment opportunities to the offshoring of jobs to nations with lower wages. It is obvious that when this occurs, as has occurred frequently in the more developed western economies, that a global free market economy is viewed with disdain, leading to an aura of protectionism to *keep what is ours* or to *bring back our jobs*, rallying cries that will never be fulfilled. In the grand scheme of a global economy, I can tell you that this notion that *the world is flat* is as dangerous of an idea of a protectionist economy when both are viewed from a twentieth century model of capital driving technological change at the detriment of labor opportunities.

So what should be done with this—should economic policy promote a policy of a global, national, or local economy? The answer to this question is, obviously, none and all of the above: frictionless markets should self-organize and emerge quite distinctively from macroeconomic definitions of the past. Nations should no longer have national economic strategies to, for example, promote a strong manufacturing sector, but rather to create a *nation of healthy prosumers* through education (in particular, related to science and technology), infrastructure (virtual and physical), and the environment (including national resources, and the proliferation of *good materials*). In nature, a sign of a healthy ecosystem is a function of the health of the totality of the organisms within it. Consistent to an ecosystem, a vibrant peer to peer national economy will become a function of the level of education of the individuals within it, a healthy environment, and an infrastructure in place that enables the individual prosumer to connect to another prosumer on his street, or one who is eight time zones away.

This is the concept of the *glocal* economy; one that is not contrived to be neither a Tom Friedman *flat world*, or a protectionist mindset that seeks to keep as much supply and demand within one's borders. Instead, economic activity flourishes through the individual prosumer rather than the institution; it matters less whether a peer to peer relationship is created local or global, thus the definition of the *glocal* market. Frictionless market activity is the best solution, and by definition, equilibrium will be achieved; economic growth will not be analyzed as "too slow" or "too fast", but rather by these almost infinite peer to peer transactions. It is a sustainable approach to both economics and the (natural and social) environment.

Reason #5: Technology as an Enabler of Peer to Peer Emergence (*Small P*), Not Planned Activity (*Big O*)

In the past, prior to the Industrial Revolution, technology was an enabler of emergence, an opportunity for economic growth and innovation to occur through the self-organization of what was often viewed to be impossible, leading to a path of humankind progress over centuries. The problem was that through peered, small scale activity, progress was limited in scale and scope. All of this changed in the late nineteenth and early twentieth century through the *super-lubricant* of oil and the *friction* of organization (the *Big Os*). Because the scope and scale was so significant due to the immense work potential of energy (oil), the *scaffolding* of bureaucratic organizational structure needed to be utilized, and this proved very successful; the U.S. was the fertile ground where such a rational approach could be successful. With increasingly advancing technology, the once fertile equilibrium between structure and innovation/growth collapsed due to disintermediation, a loss of the transaction cost economic approach that enabled high paying jobs, and thus the *multiplier effect* between supply and demand.

Therefore, today, technology feels more like a *Frankensteinian* invention, wrecking more havoc to labor than benefit, and thus creating a *divider effect*, causing flat or lower wages and therefore, negative to flat economic growth. On top of this, a growing world population and dwindling natural resources leads many economists and environmentalists to believe technology is one of the factors that will drive society off a cliff unless we slow it down to *the end of growth* model, one that appears to be against our very existence through evolution.

But of course, this is only if we choose to enable technological change within an outdated economic model; when we flip the labor (worker to prosumer) from being commoditized and now put technology in place to play this role, a case for frictionless market activity changes our path. Therefore, the ultimate value of our technological progress is not when it becomes so remarkable that it leads to a progress beyond man, such as a dystopian singularity, but rather one in that it liberates us from the constraints that threaten our ultimate well-being, as appears to be happening today. In this new model, technology becomes the hero, and not the villain; yet it is up to us as policymakers to put the right system in place for this to occur!

Conclusion

This book is a story of our past and future; of where we are heading as an economy and supply chain environment, versus where we can head as a future of billions of self-organizing nodes. It's a story of how man had learned to use natural resources, and then abuse them, and the hopes that we will soon learn that our industrial materials and products can make our natural environment better, not worse. But most importantly, this book is about a collective mindset that never existed in the first place. After all, there is no such thing as a global or national supply chain system, but rather an understanding or definition of how such a mythical entity is really a virtually infinite array of individual transactions between companies and individuals, both locally and around the world.

When anthropogenic systems, such as an industrial supply chain, reaches a *fork in the road* that requires us to make *false choices* between economic growth and environmental well-being, or worker standards of living and corporate profitability, we should realize that there are foundational questions to address. In this book, I seek to focus the reader on the foundation of our market and supply chain structure that appears to be stuck in the twentieth century. I'm certain that some policymakers will read these twenty-first century frictionless market solutions as too optimistic in regard to the possibilities of the future marketplace, but I think I have made a strong argument otherwise. Technology will continue to advance exponentially, creating a tear between labor and capital, and growing economic activity for a world population over seven billion and growing may lead to collapse, as is legitimately proven in scientific research. In the face of these two existential socioeconomic problems, there is no other option than transformational change that considers the realities of our present state. In this book, I believe that I have made the case for frictionless markets in a sober, empirical manner, based upon economics, science and technology. As the reader, you will be the ultimate judge of my solutions.

Yet regardless of what you think as the judge of this book, my gaze is out in the future toward the standards of living that I hope my two young daughters will have in the year 2030; if there is no structural change, and economic and market activity is still focused on *Big O* structures that are heavily wasteful to natural resources, I will have to agree with the environmentalists, such as Richard Heinberg, that *the end of growth* will occur; my kids will be forced to live in a world without progress and a future for their children. Yet in a parallel universe, my girls could be the benefit of a frictionless market model where they can be whoever they wish to be as prosumers; one day, they host a dinner party to earn a living, the next week, they teach a class at the University of P2P, and then they choose to develop new *good materials* in a lab, all in a frictionless manner. Such a world would be the place where I want them to live in freedom, peace, and prosperity.

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