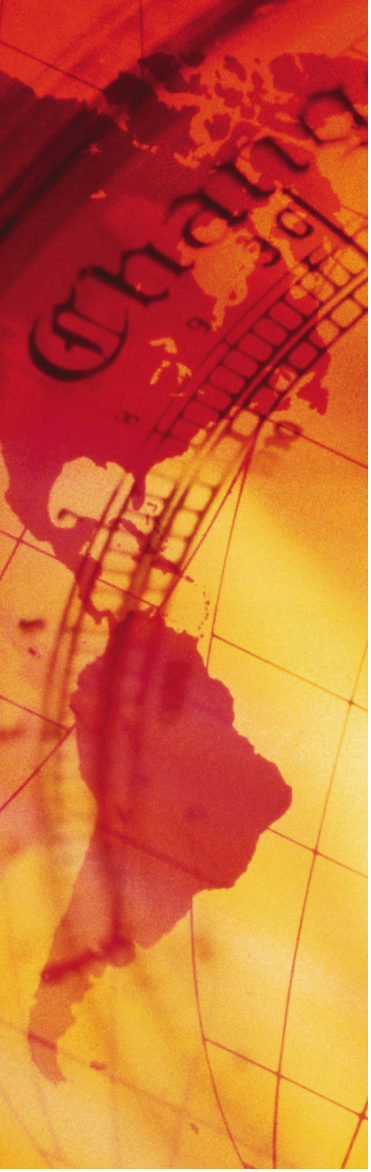

INTERNATIONAL BUSINESS COLLECTION
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Innovation in China

The Tail of the Dragon

William H.A. Johnson

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First published in 2015 by
Business Expert Press, LLC
222 East 46th Street, New York, NY 10017
www.businessexpertpress.com

ISBN-13: 978-1-60649-440-0 (paperback)
ISBN-13: 978-1-60649-441-7 (e-book)

Business Expert Press International Business Collection

Collection ISSN: 1948-2752 (print)
Collection ISSN: 1948-2760 (electronic)

Cover and interior design by Exeter Premedia Services Private Ltd., Chennai, India

First edition: 2015

10 9 8 7 6 5 4 3 2 1

Printed in the United States of America.

Abstract

A word often used today regarding China is *innovation*, as if the concept were new to the eastern country. Most people know, however, that China was a juggernaut in creating new technologies and at one time was the innovation king of the world—but that was at least seven centuries ago! Today, the great oriental power is attempting once again to take the throne of innovation for its own.

But this desire to usurp the throne, which had been diligently taken by the West during the Scientific Revolution, has placed an almost unrealistic emphasis on innovation. In *Innovation in China: The Tail of the Dragon*, Professor Johnson explores the issues and actors involved in making innovation the emphasis in China. He uses a simple systems model of innovation and various perceptual lenses. The lenses are aimed at the historical, economic, political, legal, educational and cultural elements of an innovation-based society. All of these elements are intimately related to each other in an effective innovation system. After various travels he has made to China and research on the subject, Dr. Johnson questions whether the push towards proactive self-sustaining innovation has been effective to date and prognosticates where it may be going. He cautions that although innovation is the "tail that wagged the dog" and is driving a lot of business and political activities in China these days, the dragon is awakened and that the rest of the world must take China seriously as an innovation power.

After reading the book, the reader will understand more about how innovation is happening in China and by whom. More importantly, the reader will begin a journey of learning more about where the country is going as it relentlessly continues its drive to create an innovation-based society and to become once again, in terms appropriate to its history, the *emperor of innovation*.

Keywords

China, culture, economic development, education, innovation

Contents

Preface

An expert is just an ordinary fellow from another town!

—Paraphrasing Mark Twain

Writing a book about a vast and complicated country, especially a short, concise book, is a daunting task, and I must admit that it took me a while to put pen to paper and finish this one. Besides more pragmatic concerns I had at the time (such as running an MBA program), one reason was my concern that I did not know enough about such a mysterious and reticent nation as China. Furthermore, I was concerned that people may wonder what a Caucasian from the West could say about innovation in the East. Being humble about our knowledge is important and a hallmark of careful thinkers since the time of Socrates. In my case as with others, the more I learn, the more I understand how much I do not know. But with a curious attitude and ambitious research skills people like me can search out for new knowledge and do in fact come to know more as they move along in the learning or research process. Such is my experience since my first exposure to China in 2005. Rather than suggest that I know everything about China and her efforts to innovate, let alone the remedies for her success, I can only offer my advice based on studies of successful innovation of which I am aware and my perceptions of what is happening in China based on personal and second-hand research experiences.

So what's the value here? I like the Mark Twain quote about an expert because it gets at the essence that an expert can be someone with a dissimilar experience who can offer advice from a different perspective. Although I also know that he meant to be more sardonic with the saying, for me it suggests that there is value of someone's opinion from outside the system with which one is most familiar. Sometimes it takes an outsider to tell us what we are doing before we can make sense of it ourselves. It is with this philosophy that I offer my study and thoughts of innovation in China within this book. The value I offer is a framework in which to analyze what has happened, what is happening, and what may happen

with respect to innovation efforts in China—all within less than a buck and change in pages!

My hope is that the reader will be enlightened by a number of things that they may not have known before and inspired to research further into the subject. China is certainly here to stay in the modern world's list of important countries but I do realize that I am not the first Occidental to become enamored and intrigued by the Orient. China has always seemed mysterious to the Westerner. It still provides a place that the adventurer can explore and discover new, interesting things that while being somewhat familiar are still, at the same time, foreign in nature.

I chose the title of the book as a play on the old joke about the "tail that wagged the dog." (Please see the quote at the beginning of Chapter 1.) It seems an appropriate analogy given that innovation is driving a lot of things in China these days. But in essence my main purpose for writing the book is to understand more about how innovation is happening in China. To that end, Chapter 1 discusses the structure of the book, which uses a simple systems model of innovation to examine China via various perceptual lenses.

Acknowledgments

I would like to thank a number of people who have been supportive as I wrote the book. First and foremost, I would like to thank Ruth Benner for her patience and understanding. I'd like to thank my colleagues at the Pennsylvania State University's Erie campus, The Behrend College, and, in particular, Diane Parente and Pelin Bicen, for their collegiality and support as mentor and research partner, respectively, at the school. I also thank Balaji Rajagopalan, Director of the Black School of Business, for allowing me to keep the MBA directorship an interim-only appointment and get on with my research initiatives. To all those who have helped in my understanding of China and her innovation efforts, I give my warm-hearted appreciation. There are countless people who have helped me along the way but specifically I'd like to mention Wenlin Li, Richard Lihua, Qing Liu, Lucy Lu, and Joseph Weiss—as they all touched upon this work in some way or other.

Special thanks to Scott Isenberg at Business Expert Press for sticking with me as I transitioned through the interim administrative position as MBA director at my school that almost side-lined my ambitions to write the book. Administration certainly takes up a lot of one's time. I adamantly recommend it to anyone looking for a little masochistic stimulation … tongue, of course, in cheek.

While I cite a number of sources, the book is written from my own perspective and any errors and omissions are entirely my mistake. Some of the things discussed in the book are of a more permanent nature (the past is gone and some models are universal and fixed). But many things will change as time moves on (such as the strategies of the Chinese people and their attitudes towards innovation). My hope is that both the reader and I will continue to find the topic interesting and study it as it unfolds into the future—and that the future will be bright, free, and prosperous for both China and the rest of the world.

CHAPTER 1

Tail of the Dragon—Interpreting Innovation in China

Why does the dog wag its tail?
Because the dog is smarter than the tail.
If the tail were smarter, it would wag the dog.

—From the 1997 film *Wag the Dog*

When I first visited China in 2005, I quickly realized that while business was booming and an entrepreneurial spirit existed (the kind that is more associated with business exploitation than major change), an innovation spirit was lacking. I had the chance to visit and speak with people at Chinese companies like the Baoshan Steel Company, Yanfeng Visteon Automotive Trim Systems, and the Fujikon Industrial Company. I also visited some universities such as Jiaotong University in Shanghai and the Sun Yat-Sen University in Guangzhou. All of these places were doing interesting things but innovation (true and proactive) was not one of them. Every time I asked about innovation, I got the impression that it was not a well-understood term. Innovation was imitative or incremental at best. In fact, when I glimpsed a shirt on a wardrobe rack at a television studio in Hong Kong that I visited, it seemed like an omen to me. Well, omen might be too strong a word. However, it did seem to be a symbolic message that magically wrapped up my findings regarding innovation in China during that trip. Printed on the shirt was one word—*Follow*—and I just had to photograph it (see Figure 1.1 for the evidence)!

That first trip initiated my interest in understanding innovation management in China. Later, in a subsequent visit in 2006, I witnessed the beginnings of the Bird's Nest stadium in preparation for the 2008

Figure 1.1 Picture of the Follow logo shot from 2005 China trip

Olympic Games in Beijing. Again, I visited companies and some universities like Fudan University. Change was in the air but innovation still seemed to be misunderstood, at least innovation as I was trained to see it. These experiences led me to do some research on innovation in China and culminated in a few papers about potential cultural and historical reasons (as well as political) for the propensity and lack thereof in the Chinese setting (Johnson 2006; Johnson and Weiss 2008).

Interestingly, the year that my paper "Transitions in Innovation: Musings on the Propensity and Factors Towards Proactive Innovation in China" was published, the then President Hu Jintao and

Premier Wen Jiabao unveiled a policy toward what would be described by the term *indigenous innovation* or in Chinese, zizhu chuangxin—*blazing a path*. A remnant of the planned economy perspective (I will discuss whether this is an impediment or not to innovation in general at places within this book[1]), the policy document is called "The National Medium- and Long-Term Plan for the Development of Science and Technology (2006–2020)" (MLP-2020). It called on China to become an innovation powerhouse by the year 2020. Admitting that China was yet to be an economic powerhouse, Premier Wen is said to have stated, "We (that is, China) fundamentally have to rely on two main drivers. One, to persist in the promotion of opening and reform; and two, rely on the progress of science and technology and the strength of innovation" (McGregor 2010, 4).

But China is full of paradox to the Western observer—interesting paradox, allusive paradox, tantalizing paradox. Even as crack downs take place on its citizens in Hong Kong who call for more democratic reforms, China is moving more and more toward a modern innovation-based society that needs to rely on open-mindedness and inclusive processes. While some innovation in terms of development and reiterations in improvements on technologies is possible without such egalitarian scenarios, proactive innovation in general, the kind that the former president Hu and current president Xi publically support (the kind that builds the competitive advantage of nations and allowed for the leapfrogging of military and commercial powers in the past) requires ideas to flow and a certain freedom from the persecution of error that is historically prevalent in planned economies.[2] For example, it is well established that long-term successful innovation requires some failure—if only to learn from it and spur new opportunities for innovation. Indeed, the fact that China calls for proactive innovation from the bureaucratic pen of a medium- to long-term plan is paradoxical in itself. However, it is not unheard of and can be seen as a positive step toward rebuilding the once great nation as a world power.

Indeed, at the time of writing this book China had become the world's largest economy, surpassing the United States in October 2014 from the mantle on which that country stood for over a 100 years after having taken the place of the United Kingdom in 1873—granted that much of this is due to China's vast population. However, one cannot help but be

impressed by the ability of the Chinese Communist Party (CCP) to plan such spectacular growth—at one time double-digits for years on end—or at least to seem as if they had planned it. If we peel away the layers of this fascinating and mysterious country and its inhabitants, we see that the same aspects of innovation and its success applies as in the West although with unique characteristics in terms of its own cultural milieu.

For example, Chinese characteristics of the innovation process involve patient learning (of others' standards, including nature), which has often led to the notion that Chinese philosophy promotes harmony with nature.[3] Undoubtedly, Chinese innovation practice is consistent with keeping harmony with tradition. Indigenous innovation refers to utilizing science and technology to create innovation by the Chinese that solves Chinese problems. So, as we will see, the needs and motivations for innovation in China will depend on the specific Chinese environment and Sino-examples (Sino, Cathay, and so on, are all synonyms for being *Chinese-like* or affiliated with China). The same goes for understanding the people or actors involved in the innovation environment and how everything is organized (i.e., money, infrastructure, other actors, and so on).

In this book, I utilize a simple but effective systems model of innovation depicted in Figure 1.2 to illustrate the aspects of innovation taking place in China today as well as in its glorious, invention-rich past. As a systems model (much like an ecological model from the natural sciences), it takes into account environmental inputs and systematic outputs. These inputs get transformed by the system's mechanisms or other elements over time to produce outputs, which may re-enter into the system to be transformed again or sent out into the greater environment. Each element is described in more detail in the next few pages, but suffice it to state that all innovation requires people, who may be involved in the process of innovation or merely facilitating it, such that we can help to describe an innovation system by knowing the people or actors involved in the system. While money alone will not drive innovation, in general all innovative activities are linked to money either as a facilitator of the process or a long-term output or objective. Finally, innovation requires organization or a way to orchestrate the actors and money involved in the innovation activities. Again, organization will depend on the context being examined

but it is fundamental to modern innovation processes and can be studied at the national, subnational, and organizational or firm levels.

As such, innovation can be conceptualized and analyzed by using an input–transformation–output model that helps us better organize and understand the world. In our case, the model can also be applied at different levels of analysis such that by using it we can analyze the innovation system of a nation (the topic of Chapter 3) as well as the innovation system of a firm (a topic which pervades all the chapters of the book). In this book, I use perspectives as lenses to apply the general model. We cannot understand where we are going, unless we understand where we have been. This truism of historical importance is a starting point for understanding a subject. As such, the first perspective is the historic—what were the needs of the people and how were they organized to innovate in classic Chinese history? The second perspective is the economic perspective, where at the national level the present CCP government is trying to enact the elements of innovation in order to create an indigenous innovation-based society—a classic National Innovation System (NIS) approach. The next perspective is the political, which can also be seen at the national, subnational, or regional and organizational levels, and sets the stage for a culturewide strategy toward innovation. I then tackle the legal perspective using the model to determine the actors involved in managing innovation and, given its importance for the motivation to innovate, protecting intellectual property rights as well as general legal aspects of the Chinese environment that support or impinge on innovation practices. The next perspective is an element of the NIS but is also fundamental to the core generic systems model of innovation—namely, education. Here, I refer to not just so-called STEM graduates (for science, technology, engineering, and math) but also to better increase the education of all citizens, which is necessary for a highly productive and self-sustaining innovative society. For example, even ordinary citizens need to have some level of competence to use a technology if that technology is going to be successfully adopted and distributed in a society. Education is a public good that helps not only the actual person receiving the education but also the society in general—which is the fundamental argument for universal education. Finally, I take on the cultural perspective, which provides a unique flavor in China especially in terms of the

Eastern philosophical traditions mentioned earlier, before wrapping up with a take on how the model might describe the future Chinese innovation-based society—if President Hu is to have his legacy.

Definitions and Explanations

Innovation

There are many definitions of innovation depending on the objectives of the author using the term. In general, innovation is seen as something that is new. But it may sometimes be difficult to determine newness, so it is best to view innovation as new to the particular situation. For example, a different version of the latest music equipment might be viewed as incremental in nature—slightly new but not totally new—yet still be considered an innovation. Also, in the media, we often refer to innovations as *things*—Apple's iPod itself might be referred to as an innovation or an innovation in the introduction of the new multicolored 32 GB version. However, because I am interested in how one manages the aspects of innovation, I often view innovation as a process and not a product. Instead, the product of innovation is an invention or a service (or indeed an intermediary process) that can be further utilized toward some end goal. In business, that goal is profit via commercialization of the invention or service. Indeed, a classic definition of innovation from Ed Roberts was "Innovation = Invention + Commercialization" (1991). For the purposes of analyzing innovation in China, I use the following definition. Innovation is the process of developing products and services utilizing knowledge and skills from various and appropriate domains for the purpose of achieving some positive outcome.

Note again that it is defined as a process and not the outcome itself. Whether we are talking about the factors leading toward China's ability to create new knowledge or a Chinese company's capabilities for introducing a new product to the market, we are referring to innovation as the underlying process that leads to these positive outcomes. Later in the chapter, I will discuss the outputs of this innovation process. These outputs are often referred to as *innovations* (indeed innovation could be seen as process or product), but to avoid confusion, I will refer to them as innovative products and services or product innovations.

Needs

The classic statement on invention is that it is the offspring of necessity, that is, "necessity is the mother of invention." If, as we saw earlier, innovation involves invention to some degree then we can be sure that successful innovation requires some sort of need. Indeed, to innovate for the sake of innovation can be wasteful and counterproductive. In the generic systems model of innovation, the needs of different actors will vary, but, in general, the *necessity for necessity* as an element of the propensity toward innovation will always stand. As pointed out by Maslow in his famous hierarchy of needs, the existence of unfulfilled needs leads to the motivation to fulfill those needs. At the national policy level, motivation often comes from the association of economic prosperity and national defense that emanate from the technological innovation abilities of the nation's people. At the firm level, it comes from its association with long-term profit and productivity. At the individual level, motivation comes from an innate sense of satisfaction that certain people—natural inventors, accidental innovators, and so on—have when innovating. It may also emanate from the financial and social rewards often reaped by innovators, though this depends on the innovation culture and milieu such that innovation is more likely in cultures that provide both financial and social (e.g., awards for research excellence) recognition to individuals. Indeed, it can happen the other way, some cultures *eliminate* or discourage innovators—which would be a negative reward for being innovative. This explains cultures where innovation does not happen.

In a general sense, the motivation for innovation comes from the need to change, to adapt, and to improve the productivity of human activities. Indeed, a close examination of the history of humans reveals that it is innovation, defined specifically for our purposes earlier but generally considered as a process of creating new tools for positive human use, which helped mankind climb down from the trees and take up the mantle of *king of the animal world*.

In China, the need for innovation is both top-down and bottom-up. It is top-down as directed by the MLP-2020. The Chinese government has always recognized the need for self-sufficiency even when China was ruled by an emperor and the mistrust of foreigners and foreign intensions is pervasive and not historically unwarranted. In modern China, the need

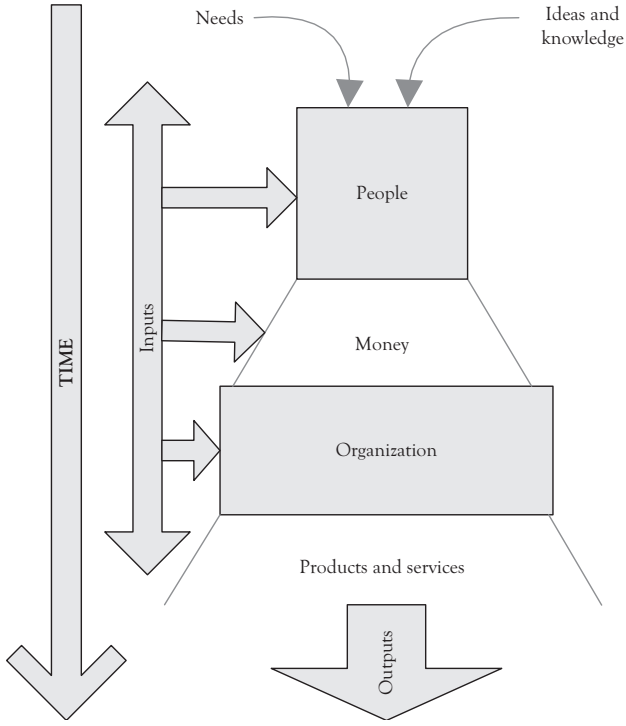


Figure 1.2 Generic systems model of innovation

to solve many of the domestic issues presently plaguing the country such as atrocious air quality, maintaining safe and plentiful food supplies, and keeping the *average* citizen gainfully employed has driven greater focus on innovation and particularly an emphasis on science and technology.

Actors

All innovation requires people. Actors are defined by the roles people play in influencing innovation activities. For example, actors might be scientists or engineers or government policy makers. Customers themselves can play a strong role in innovation both as input to the creation part of the process as well as the ultimate measure of innovation success (when they buy the innovative product). Note that I define actors in terms of roles despite the fact that we are talking about real people. Each actor has a role to play in driving the system to efficient and effective utilization of new

products and services. However, note that one person can play many roles and thus be seen as an actor under different situations (e.g., a government policy maker can also be a customer). In general, it is useful to be able to identify actors by their characteristics and their influence on the process of innovation. One typical example is the varying characteristics of actors in the diffusion of innovation process. In that model, actors can be broken into various groups such as early adopters and laggards, which can be helpful in managing the responses for marketing a new product in a marketplace and can explain many of the patterns of diffusion that we find in new product introductions. Actors also play a major role in models of NIS that I examine for China's case in Chapter 3. Again, knowing the responsibilities, characteristics, and influences of different actors is useful in understanding the propensities toward innovation, or lack thereof.

Table 1.1 depicts the general characteristics of actors in an innovation system, which may be used at the international, national, and regional level. It is also possible to use the characteristics in the top row to describe actors within the innovation system of an organization. In general, actors can actively develop new innovative products and services or they may support the development by facilitating the process—for example, by providing funding or other necessary resources to the innovation process such as information or technology. An actor may also influence the process without actually facilitating it such as when consumer preferences influence what features of a product will be focused on or public opinion determines the types of innovation that governments finance, such as the need in China for better antipollution technologies. As mentioned previously, actors may again play multiple roles though this is often likely to be in various forms of innovation. That is, an organization or person might be a facilitator of one innovation project but the developer of

Table 1.1 Some generic examples of actors in the innovation process

	Developers	Facilitators	Influencers
Public	Government laboratories	Government research centers	Government regulatory bodies
Private	R&D labs of companies	Government laboratories	Customers
Mixed	Collaborative R&D projects	Multiorganizational research support projects	Standards collaborative

another, but for any particular innovation project the model is likely to be mutually exclusive.

Narayanan has a simpler depiction of types of institutions based on western innovation systems that does not include influencers or mixed types (2001, 28).

Actors may also be characterized by whether they are government or public entities or private organizations. The use of triple helix innovation, which involves government, industry, and quasipublic organizations like universities, has created extremely complicated organizations that are aimed at undertaking innovation projects that one actor alone could not undertake. The *mixed* category refers to such cases. These classifications have distinct effects on issues of control, funding, and where the residual profits of innovation will go.

Using the terminology of recent years, we can also refer to people or actors as human capital, specifically when we want to emphasize the investment responsibilities people have in the innovation process as active innovators (rather than outside actors who merely influence the process via their policy introductions and so on). The concept of capital is also useful for measuring the amount of built up reserves in a country or company. Figure 1.3 depicts various types of capital adapted from a well-cited paper I wrote a number of years ago (Johnson 1999). Using this categorization scheme allows us to model and measure those factors that both influence and also indicate innovation activities. For example, financial capital (as discussed later in the text) helps attract human capital. If we think in terms of a new company, at first financial capital might be drained as we hire more people and develop our human capital. As human capital rises over time, other capital stores may increase as well, such as intellectual capital, which eventually will positively impact financial capital, hopefully, in a self-reinforced positive feedback loop (Johnson 2002). All capital elements feed into the value definition of the company or its market value. Again, this can be extended to a national perspective so that we can think of the value (or potential for creating value) as the sum total of all capital stocks of the country. Note that, like market value, this is a perception that can change as more or less is known about the capital stocks of the company. But in a perfect market, an economist would expect these to equal the projected cash flows of activities in perpetuity. Of course, who

has ever seen a perfect market! The model is useful for our purposes of examining China and the efforts of both its government and companies toward building an innovation-based society. Capital in its various forms is often seen as so important to the economic development of a country but can be applied at both a national and company level.

Money

Money is both the lubricant and glue that supports the grouping of activities necessary for innovation to be successful. It is the *transactional* resource that can be utilized to acquire other necessary resources for innovation. For example, money is used to pay the salaries of corporate scientists or buy the machine needed for testing some process. As noted, money by itself will not lead to innovation in any form. One can certainly buy an invention or a service that may be considered innovative, but the process of innovation, as defined here, requires more than just the financial investments. Thus, money (or investment) is necessary but not sufficient for innovation. Indeed, a research that I currently conducted with my colleague, Dr. Pelin Bicen at Penn State University, suggests that much can be done under conditions of resource constraints (Bicen and Johnson 2014; Bicen and Johnson 2015). Indeed, in many cases, innovation and the behaviors associated with radical innovation are driven by the resource constraint situation. And that constrained resource is often money. However, even if it is not money, cash can often be useful in facilitating the acquisition of the missing or constrained resource (though not always!). For that reason, I define money in the context of innovation as the supportive *transactional* resource for acquiring the nonmonetary resources needed for innovation. The model depicted in Figure 1.2 represents the investment needed for the particular example of innovation being examined.

The concept of capital is again useful here. Money is represented to some extent by financial capital, which is the economic or fiscal power of the company or country to fund its innovation activities.

However, as depicted in Figure 1.3, the actual market value of a firm or the GDP-potential of a country is made up of both financial capital and intellectual capital—at least if you subscribe to the theory of the importance of knowledge to economic development and sustainability,

which is pretty much *status quo* today. This means that we can get a better idea of how well the innovation system is doing by understanding the other elements of productive capital—human, relational, and structural. I do this through the book in relation to how China stands so far—as a work in progress. General asset types are illustrated in Table 1.2, which are associated with each type of capital. Examples of capital that can be transcribed to the Chinese context are also listed and the chapters given where some discussion is made.

Organization

The intellectual capital framework of Figure 1.3 and Table 1.2 is also useful in looking at the organization, which is the means by which the rest of the innovation system comes together to create an innovative product or services and make changes to the production and process capabilities of a firm or country. On a simple level, people and money by themselves will

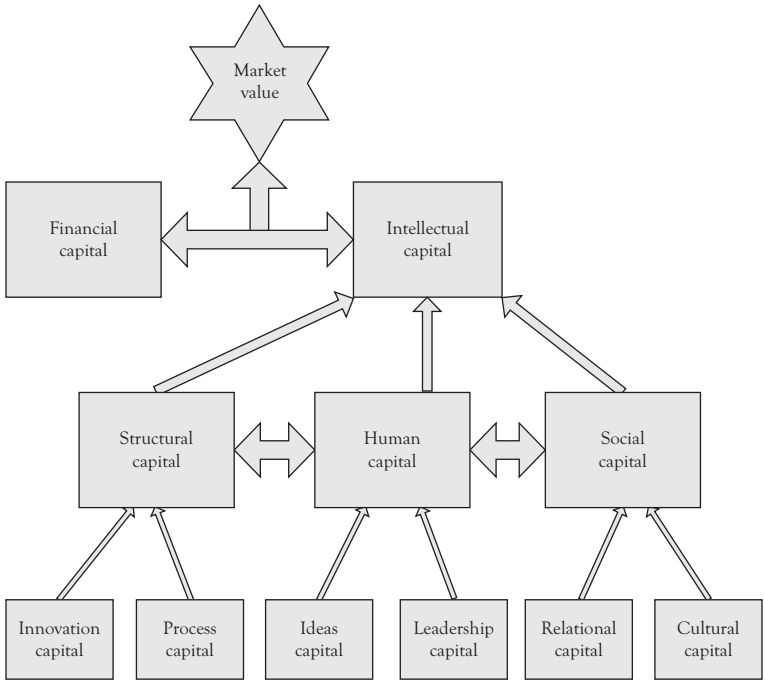


Figure 1.3 Underlying market value and the elements of capital

Table 1.2 Generic examples of capital concepts

Type of capital		Asset types	Chinese scenarios (chapters covered)
Human capital	Ideas capital	• Knowledge-based workforce • Assembled workforce • R&D projects	S&T focus of MLP-2020 (Chapter 3) STEM competence workforce (Chapter 6)
	Leadership capital	• Experts • Managerial competence	Cost leadership strategies (Chapters 3 to 7)
Structural capital	Innovation capital	• Intellectual property • Infrastructure	Increased patents granted (Chapter 5)
	Process capital	• Practices and procedures • Trade secrets	Increased focus on innovation-based society
Social capital	Cultural capital	• Internal relations	Cultural influences (Chapter 7)
	Customer relations	• Competence-enhancing customers	Education of general Chinese population (Chapter 6)
	Supplier relations	• Supplier alliances	Economic system (Chapter 3)
	Stakeholders relations	• Regulatory authority	Political system (Chapter 4)

not innovate. It takes an organized effort to do that. At the firm level this involves things like the creation of an R&D unit or a production development team to systematically organize the processes supporting innovation. At the country level, this might be seen in the creation of standards organizations or research support groups that help organize by bringing financial support to inventive actors in the macroeconomic environment. Either level can utilize the intellectual capital framework as a general tool for understanding what is going on at that level.

For example, the human capital consists of the ideas and leadership brought forth by specific actors in the system. At the firm level, these could be project champions and gate keepers. At the national level, these could be organizations like the Chinese Academy of Sciences existing to support scientific development in China. Relational capital helps describe the connection made by the actors representing human capital. Without adequate relational capital (in China, the well-publicized concept of *guanxi* is an example), the process will not work.

Structural capital represents the accumulation of the fruits of human and relational capital. The often measured concept of intellectual property and all its various forms (e.g., trademark, invention patents, copyright, and so on) is an example of structural capital. It is important to point out that this is the result of the process of innovation and not innovation itself, as I argued in some papers on managing innovation (e.g., Johnson 2002). As such, it is important to take the entire system into account when measuring innovation productivity and potential.

Output

Of course the final outcome of the innovation process should be some sort of novel, creative product or service. Researchers and practitioners argue the extent to what constitutes novel and creative. Indeed, this can be a matter of great contention. In the general systems model used here, it is constructive to think of the outputs of the system. Because my own research is often focused on the for-profit business situation, the output is usually some sort of commercial product or service. That is what we mean in general and in most situations. However, in analyzing China and any other national system of innovation with various actors, the actual outputs within the system might indeed be other inputs within the systems—hence the arrow going back and forth in the depiction of the model in Figure 1.2.

Some often utilized frameworks for innovation are predicated on classification systems of Abernathy and Clark (1985) and Henderson and Clark (1990). These are based on whether the innovation involves component knowledge change and configuration change. Figure 1.4 illustrates the types of innovation change identified by various models of innovation classifications. The models help us identify the novelty and creativity of the innovation product or output by questioning the amount of change brought about by the innovation.

This is also helpful because by determining the amount of change that an innovation entails, we can also determine the complexity of the innovation process and the types of resources necessary for the innovation.

Utilizing these frameworks in analyzing China's innovation efforts, we will see that much has followed the natural trajectory of moving

	Great change in component knowledge or technical capabilities destroyed	Little change in component knowledge or technical capabilities preserved
Great change in configuration knowledge or market capabilities destroyed	*Radical or Architectural*	*Architectural or Niche*
Little change in configuration knowledge or market capabilities preserved	*Modular or Revolutionary*	*Incremental or Regular*

Figure 1.4 Innovation classifications

Source: Adapted from Abernathy and Clark (1985) and Henderson and Clark (1990).

from incremental innovation, where not much change exists in either the knowledge of specific technologies or the way that they are linked to one another toward higher levels of innovation effort. Here, we can add cosmetic changes that allow a company to introduce its own product line such as a new cell phone that houses existing technologies in a similar manner to other cell phones in which only a few new features are included. China's companies have excelled in such incremental innovations and have moved toward dominance of architectural-type innovation where changing the configuration of system components in novel ways creates value. This is particularly so in the manufacturing field where cost innovation is perfected and newer "capabilities of ultra mass-flexible production are unique to China" (Breznitz and Murphree 2011, 16).

Breznitz and Murphree make an interesting point about cost innovation, but their finding may reflect the major problem for China and the world in general as it changes over time. That is because their thesis makes sense while the world is a tightly networked supply *chain*. but it also suggests that China will always be dependent on foreign technologies unless change happens (2011). This would have tremendous effects on national and economic security for the Asian country. It is also not entirely clear whether the Chinese will become truly innovative in the near to mid-distant future. For example, as the rest of the world loses its dominance in some technologies due to the Chinese *outbidding them*

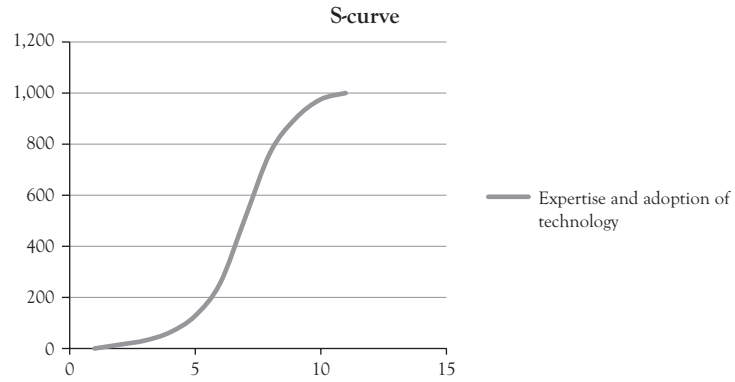


Figure 1.5 Concept of the S growth curve

(e.g., in high-speed train systems production), the production of novel foreign technologies may be expected to decline. This is particularly true given the theory that product innovation is tied to process innovation and early adopter usage.

Finally, I include the concept of the S-curve that is also prevalent in studies of innovation management and technology adoption. This is useful to map changes over time in degree of expertise of a new technology or the adoption of a new technology or product innovation. As seen in Figure 1.5, it gets its name from the often recognizable S shape; however, although it is important to point out that it need not be as neat and precise as drawn here. I use it in the book mostly as a tool to gauge the growth of expertise and new technologies in China.

Perspectives on Innovation

Innovation almost by definition involves multiple disciplines. For successful outputs at the organization level any particular innovation effort may require engineering, design, marketing, production, and general management expertise. At the national level, innovation is seen as the enabler of change and leads us to a more prosperous future because innovation is, in essence, the process of determining how to make things better, do more with less, eliminate that which is bad for the environment, and so on. Certainly, by-products of innovation can sometimes be harmful, like pollution issues, but overall the process is meant to bring us

closer to a better society overall for all involved. Few rational individuals would argue that mankind is not better off from the myriad of advancements in science, medicine, and technology—despite the headaches such advancements might bring—I am thinking about a study I recently read about the effect of checking e-mails throughout the day and the resulting personal stress!

My hope is that China can move toward its goal of becoming an innovation-based society in order that it can be prosperous, more democratic (not less), and help to clean up the mess that over expansion has wrought on its environmental health. However, this is not an easy task and China, in particular, has its work cut out for it. Innovation is never easy, precisely because it depends on so many different perspectives to work. In fact, classic work on innovation in organizations started off by trying to figure out how various functions within the organization could work better together. Initially, it was found that marketing departments would clash with production personnel due to turf wars and power politics. Today, we have realized that such clashes are counterproductive for all parties involved. Both nations and companies have discovered that they must innovate or become irrelevant. But understanding the perspectives on innovation and how they can *get along* is still a must.

In the rest of this book, I utilize the models and frameworks discussed in this chapter from various perspectives to analyze China's innovation efforts. Because one cannot know where one is going without knowing where one has been, I start with the history of innovation in China. This is a vast topic that I only touch upon briefly but it will give the reader a sense of where the Chinese are coming from and perhaps make them more curious to read the classics on the subject. History is also very important for innovation due to the concept (here is another one before I end the chapter) of path dependency in technological and innovation trajectories. That is, in short, where we end up will depend on where we were.

After the historical minitour, I explore the economic perspective, which drives much of the desire for innovation because most prosperous economies are also innovation-based ones.

CHAPTER 2

A Historical Perspective on Innovation in China

China's territory produces all goods in abundance, so why should we buy useless trifles from abroad?

—Ming Emperor Zhengtong/Tianshun (Gao Zong) quoted in Ju-k'ang's "The Causes for the Decline in China's Overseas Trade Between the Fifteenth and Eighteenth Centuries" (1984).

A Beginning

How a Method of Grafting Plum Trees Led to the Discovery of China's Ancient Ingenuity

The year was 1943 and a middle-aged scientist from England was stationed in Yunnan when he stumbled across an interesting find (Winchester 2008, 65). His training was in biochemistry, and therefore, he was familiar with biological processes and, for this case in particular, botany. In fact, he had only earlier written a well-received book on biomorphogenesis. At first, just curious about the unfamiliar culture of his Chinese surroundings, he watched a Chinese gardener perform some duties on the grounds he visited. However, as he examined the Chinese caretaker closely, he found the specific way in which he was grafting fruit trees to be peculiar and different from what he was used to seeing. It was not the same technique used in the West but nevertheless appeared to be an effective process for grafting.

That encounter led the scientist to ask whether or not China might have developed such effective but different techniques independently many centuries ago. At the time, China had been criticized by some in the West as being *backward* and unscientific in its ways of doing things.

This new experience suggested to the scientist that perhaps China had just developed in a different but entirely effective manner. (It is sometimes explained that this path might be seen more as pseudoscience than science, but nonetheless technological development happened.)

So began a journey of discoveries that was to demonstrate the innovative powers of ancient China. For example, this first observation was addressed in one of the great tomes later compiled by the scientist mentioned earlier. There it was stated that the grafting of a red orange tree was first documented in 13th century China (Needham 1986, 107). That book was one of the volumes of work that recognized and meticulously catalogued China's innovative past. It is called *Science and Civilisation in China*, Volume VI, Part I, *Botany.*

The technological inventions that were discovered in ancient artifacts found during the scientist's journeys through the war-torn country, and now attributed to China, were even more pronounced. Like the famous tale of Sir Isaac Newton and the falling apple, a casual observation of nature on some summer day culminated in the understanding of a new discovery. In this case, it was that China was not the backward country many had thought it was back in the 19th and 20th centuries—or at least, it had not always been a backward country. It was rich not only in imperial history but also in a history of technological and innovative productivity.

One major lesson from all of this was that nothing is stagnant—all things change. Supposedly, foreign visitors during the time of Marco Polo delighted in the fact that well-made bridges were located in what seemed remote and faraway places—void of any population that would explain the existence of such expensive projects. The reason for these *bridges to nowhere*, of course, was that there once *was* a population in the region that did support their existence and indeed helped in their creation. However, as empires rise and fall so do regional populations. The existence of these bridges demonstrates the wealth and technological prowess of ancient China but it also shows the ebb and flow of historical development. What once was a great technological empire had now lost its edge, retreated inward, and became the mysterious orient.

That is where our scientist entered the picture to throw back the veil of time and reveal her ancient secrets. Today, the question we ask is this: Can China revitalize its historic penchant for invention and discovery?

It is certainly a question of importance to both China, where the government has made innovation a modern mandate for the nation, and the rest of the world that must compete and cooperate with this most populous country in the world.

Applying the Generic Systems Model to the Historical Setting

Table 2.1 lists some of the elements of the generic model that seem to apply to the historical setting of imperial rule, which China was under for centuries—in fact, up until the 20th century.

A Glorious Past—A Tale of the Dragon

A well-known situation in the annals of China's ancient history has to do with China's descent from technological superiority around the time in which the Scientific and Industrial Revolutions in the West took place. From that moment onward, consensus exists that the West has dominated much of the scientific and technological innovations of the world (and perhaps other innovations such as those that are organizational and political). This phenomenon has been called the *Needham Question* or the *Needham Paradox or Problem*. It is named after the famous Cambridge scientist Joseph Needham, who is the actor presented in the opening case of the chapter. Needham fell in love with China after being reluctantly stationed as director at the Sino-British Science Co-operation Office in Chongqing during World War II. He then dedicated his entire life to discovering and cataloguing all of the inventions created within China's boundaries. The *question* that Needham posed was "Why, after centuries

Table 2.1 Generic systems model of innovation from the historical perspective

Perspective	Needs	Actors
Historical	China as the *middle kingdom* Self-contained and isolated	Emperor Subjects: bureaucrats, labor
Money	**Organization**	**Outputs**
All is done in the emperor's name	Legalism: Confucianism	Innovations that support the imperial constant

of technological superiority in the world, did China lose its position as world innovator to the Western-based countries?"

This book to some extent attempts to answer some aspects of that question by bringing into the analysis various economic, cultural, and political factors that promote or demote propensities toward innovative activities. The Needham question does point out the importance of realizing that China, as a country and region, has housed, and continues to house, a vast array of potential human and intellectual resources. The human and intellectual capital was introduced in Chapter 1.

In this chapter, I examine as briefly as possible[1] what China was able to accomplish during its tenure as the *world's innovator*. For the purposes of our interests, which are to understand how China is attempting to once again become an innovation producer, we will examine some of the factors that seemed to support the types of innovation seen in historical China. As inherent in today's concept of a National Innovation System (NIS), the inventions that came out of China (or were produced but not exported) had characteristics indicative of the economic, cultural, and political systems of the day.

Needham's Question Revisited

For centuries, China built its empire on the innovation of its people. While Great Britain in the West was innovating in its own right on political change with the introduction of the Magna Charta, a Chinese entrepreneur was trying to promote the interesting invention of a coin-operated pencil dispenser around 1076 AD (*Business World* 2001). Classically, Francis Bacon stated that the most important inventions of the world at his time were paper, gunpowder, and the compass. They all originated in China.

Many of these inventions can be traced to the *needs* of the bureaucratic elite (the main *actors* in the innovation system) that existed in China at the time. Despite the notion of the Emperor as a monarch-type ruler, Chinese society was heavily dependent on the organized structure of government. Harmony in society is a well-known trait of Chinese political and philosophical perspectives and even the emperor had to play his proper role in organized life. Similar to today's notion of ceremonial roles

in modern monarchies, emperors were expected to partake in ceremonies often revolving around agricultural duties. As today, where more than a billion mouths exist to feed, the land and the water needed to be worked effectively. This was paramount to the wealth and success of the country. Indeed, throughout Chinese history when the agricultural system failed, or some natural disaster materialized to wreak havoc on the people, the person most likely to pay a heavy price was the emperor himself.[2]

While the emperor was the supreme leader, he was also the conduit to the heavens, and it was expected that he act for the people in interactions with the heavens. As such, scholars argue that this connection and the responsibility of the emperor led to a focus on administrative functions to manage complex systems such as waterworks, calendars, and the workings of the cosmos. This resulted in the world's first water bureau and astronomy and astrological studies—all important to the management of agriculture and food supplies (and examples of *organization* in the innovation system). Technologically, these organizational structures produced a vast array of technological innovations. Bridges, dams, water control systems, and canals were developed to aid in agricultural and infrastructure needed for an agrarian-based civilization. Solar and water clocks, calendars, and the mathematics needed to understand the movements of stars were developed to manage the cycles of nature and predict issues that might disrupt the social harmony desired by the Chinese people. Ultimately, a system of bureaucratic elites based on the principles of Confucian and legalist philosophies was created, which was necessary to manage the important endeavors described earlier. Memorization of the classic texts and the rules of the world took extensive concentration and effort and not many were able to pass the examinations. The invention of paper and printing was necessary in order to study for the arduous tests.

In general, most of these early Chinese inventions had nothing to do with commerce and were not commercial in nature. The currency of the day (*money* in our model) was the be-all and end-all will of the emperor. In fact, Confucian belief, similar to the practice of Catholicism, frowned upon usury and commerce. Indeed, many laws were enacted that prohibited merchants and the business class of society from wearing silk clothes or riding horses because these individuals were considered beneath these privileges. While trade made many people rich in terms of

economical wealth, this did not translate into political prestige or power. The coin-operated pencil dispenser mentioned earlier, if it were meant to profit the inventor, would be seen as an outlier in the world of Chinese inventions.

Unlike the West, where a number of innovations like the Long Bow were developed for military strategy, the military value of a number of Chinese inventions were only utilized later in the history of the invention. Gunpowder is a case in point. The Taoist alchemists discovered the effects of sulfur and saltpeter in their search for the elixir of life. Only after the *discovery* of gunpowder and its powerful effects on life and limb were known did the government move to create a monopoly on the ingredients used to make it. An imperial system of examinations was developed to organize and train people needed to run the bureaucracy. Those with brains were expected to study and rule; those with brawn were expected to work for the good of society. In ancient China, this was embodied in the two Confucian concepts of *wei* (civilized culture) and *wu* (military force). However, sooner or later the technologies for warfare were utilized. In China, gunpowder helped to create cluster bombs that could be used on advancing troops. It has been noted, however, that it is ironic that the very militaristic technologies first invented by the Chinese (such as gunpowder) were actually used against them by invading foreigners many years later (Merson 1990).

Answering the Question—Regarding Innovation Output

So what went wrong?

There are a number of different arguments for the problem of China's drop from technological superiority that led to Needham asking his famous question. One thing is clear, it was during the rule of the Ming dynasty that China turned its back on the Western world and withdrew its once glorious navy from the high seas. That precipitous moment appears to mark the beginning of the fall of China's place as the most innovative country of the world. Merson (1990) contends that the retreat and retrenchment was the result of the relative inability to tax the international trade routes via seafaring vessels and the concentration on defensive modes against the existential threats to the north and

northwest. Arguments for the loss of innovative power that happened next fall into two explanations—(1) demand-side perspectives that argue that there were no longer any significant demands for innovation and (2) supply-side perspectives that argue that there were no longer sufficient intellectual and human capital available.

Demand-side arguments revolve around factors such as the plentitude of labor that was available to do work. As such, with plenty of labor at one's disposal, there would be diminished returns for innovating on productivity. Furthermore, there was no substantial market for invention as trust held between city states was quite low. Inventing a new process or technology did not guarantee that the inventor would benefit from it.

Supply-side arguments revolve around factors such as lack of supply of inventors and an inventive spirit. For instance, it is argued that there was no *scientific revolution* in China and that such a situation would not allow for the scientific thinking needed to spur invention. (This, of course, ignores the fact that many technologies have been developed without a clear connection to science). Also, specific to China is the lack of sufficient rent-seeking behaviors by potential innovators. For example, as mentioned previously, young intelligent individuals (if it were possible for them to do so in terms of family and wealth) focused their attention on completing and passing the imperial exam rather than other creative pursuits that would take time and energy away from this important goal. I, myself, have argued elsewhere that this focus on test-taking and knowing the classical texts by heart led to the importance of rote memorization, which is still a predominant perspective in China's extant educational system (Johnson and Weiss 2008). Chapter 6 will discuss more on the topic.

Recently, Chen (2007) rejected both the demand- and supply-side arguments and took a more NIS perspective to understanding the Needham problem. He asserts that the failure of China to continue its technological superiority (and the subsequent ascent of Europe during the Industrial Revolution) was due to a formal patent law and a substantial market for inventions. Essentially, this argument is based on incentives and fits with the main truism that "necessity is the mother of invention"—that is, one does not invent unless there is an incentive to invent and some long-term advantage is gained for the protagonist.

Chen (2007) also has an interesting fictional allegory in examining the historical case of James Watt and the steam engine. By placing Watt in the context of historical China, it is easy to see that the necessary structural elements of the economy and legal institutions would not allow for his successful invention. Indeed, Chen (2007) makes a powerful point that if Watt was born Chinese, the invention of the steam engine may never have happened! But of course, we are all made up of our experiences, which are immersed in the contexts we find ourselves within. (We will see later the importance of the contextual milieu to innovation.)

Liwei Wang (1993) also argued that the cultural traditions of China were inimical to patent law and thus resulted in lack of adequate protection for inventions and the necessary motivation to innovate. Historically, the Chinese emperor was the supreme leader and the ultimate arbitrator in all matters, both earthly and heavenly. He was not just above any law that existed, he was the law. As such, traditional Chinese society was in many ways inimical to property rights as well, which might explain how the Chinese easily accepted socialism as their modern political doctrine. Any invention for which the inventor was noticed essentially belonged to the emperor, if he so wished. If he was not happy with the invention, such an individual might be less than well off.

The argument that the historical system of China was set up in such a way as to discourage individual initiative with a lack of individual ownership rights helps to explain how the inventions that were created in historical China were possible. For example, many of these inventions were specifically tied to the bureaucracy associated with the imperial examination and its magistrates—for example, paper. Other inventions were associated with the power of the imperial guard—for example, gunpowder and the compass for navigation purposes. Most of the original inventions of China were not based on science—at least from the perspective of *Western scientific philosophies* and the scientific method. Also, many traditional theories of nature lack the analytical methods for true scientific categorization.[3] That is, it is more appropriate to think of these as pseudo sciences based on analogy rather than on phenomena, which can be measured and tested.

China certainly stepped backward technologically when the Ming emperors decided to isolate themselves from the rest of the world. Modern

Sino history did not help either. After the collapse of the Chinese Empire system resulted in the last emperor of the Qing Dynasty, Puyi, China fell into the verge of civil war, only slightly checked by the invading Japanese forces. The aftermath of the turmoil surrounding the first part of the 20th century, which included two World Wars, was the creation and sustainment of the Chinese Communist Party (CCP) and the People's Republic of China. At first, the CCP did an admirable job with upgrading the basic education of the people and setting up a successful agricultural system of collective farming. However, Mao Zedong and his Chinese party elites were less enamored with intellectual learning and less knowledgeable of technological systems and industry. They lead the major cultural and economic movements such as the Great Leap Forward and Cultural Revolution, which together almost entirely wiped clean the creative and intelligent brain trust of the nation. During only a few other times in history did the theory of human and intellectual capital and its connection to the wealth of nations seem absent.

The Cultural Revolution, for example, was a backlash by the communist government against all things perceived to be intellectual within the People's Republic. It comprised most of the early decade, taking place during the 1970s. During the political persecutions, teachers, doctors, and others of high education and positions were intimidated into obscurity, imprisoned, or killed. The era was reminiscent to the dark ages of European society when a similar environment in which ignorance trumped knowledge led to a decrease in the general well-being of society. In such dark environments, innovation and creative thought is driven out—to lurk in the hiding spots, if at all, in a type of clandestine, suspended animation. Luckily, in both these cases, the light eventually shone through. I will return to the implication of China's Cultural Revolution when discussing education in China and its inevitable effect on innovation.

Only after Mao's death and the resurgence of one of his strongest supporters (but thankfully more liberal minded—at least to some extent) in the form of Deng Xiaoping was the economic and technological future of China allowed to grow in a capitalistlike manner. Deng Xiaoping's reforms of 1978 led to the notion of *Capitalism with Chinese Features*, which has turned the country from an undeveloped economy to one of the largest in the world in less than a half century.

As explored in the remainder of this book, China is now a major technological and economic force in the world. It has come a long way from the days in which Joseph Needham had to ask that question about why it did not maintain its technological superiority. The questions now are (1) where is it going? and (2) when can it be considered a true innovation-based nation, if at all? While there are many questionable issues regarding its true innovation capacity and capabilities, there is little doubt that the country is once again involved in moving the globe's technological progress forward. Or at least it is trying to. We end the chapter with a case in point that harkens back to the beginning.

Case: Full Circle into the Future—Beijing Genomics Institute and Biotechnology in China

The open vignette of this chapter demonstrated the intriguing way in which the Chinese approached the grafting of red orange trees many centuries ago. This historical example might be seen as a vague beginning of biotechnology or at the very least the use of techniques to manipulate nature for the good of mankind. Today, Beijing Genomics Institute (BGI), now located in what was an old shoe factory in Shenzhen, is paving the way to the future of biotechnology in China (Hilgers 2013).[4]

The biotech firm started in Beijing in 1999 but is already becoming a well-known company worldwide for its important work on genome sequencing. It was involved in the International Human Genome Project, decoding 1 percent of the genome sequence and is now analyzing some of the data. The company created the first diagnostic reagent of the severe acute respiratory syndrome (SARS) virus, which plagued much of the world in the early 21st century. It is now involved in numerous sequencing projects related to a number of important genome mappings and other high-profile endeavors.

The company is private but it helps that it is still *favored* by the Chinese government (the importance of Guanxi [i.e., network connections and favored ties] to business and technological development in China will be discussed later). Indeed, the government has mandated biotechnology as one of the seven key industries targeting it to account for 15 percent of total GDP by 2020 (Khan 2011).

BGI has without doubt done much good for the world in its sequencing work that can be used to help fight deadly outbreaks like SARS and recently a deadly form of *Escherichia coli* bacteria that was terrorizing Germany in 2011. Indeed, the company has advantages over similar companies in other parts of the world because it is less hindered by regulations trying to limit the potential negative aspects of biotechnologies and genetic modifications. Apparently, BGI plans to move planned parenthood into a *brave new world* with offerings of genetic selections for intelligence traits such as potentially important genes for mathematical prowess in human beings. It is also the owner of the world's largest pig cloning center. The good and bad that can be done with such technologies, while beyond the scope of this book, is a hotly debated topic. While countries like the United States have hampered the development of genetic engineering, in some cases making it illegal to utilize technologies using stem cells, for example, other parts of the world like China and Singapore have embraced the technology.

In 2003, a mandatory survey by the Shanghai Science and Technology Commission of the Ministry of Science and Technology revealed there were exactly 158 biotechnology-based firms in Shanghai. About three-quarters of the firms were in the manufacturing sector and the same amount employed less than 50 employees. Biomedicine accounted for the majority of biotech products (Beuzekom and Arundel 2006). Findings of joint research published in the journal *Nature* in 2012 are indicative of the international connection and progress being made by Chinese biomedicine (MOST 2012). The research was conducted by Yu Yongchun at Fudan University's Institute of Neurobiology who collaborated with a team headed by Shi Songhai at the Memorial Sloan-Kettering Cancer Center in New York. Indeed there are some warnings that America could be losing its competitiveness on such technologies, particularly in ethically sensitive areas because of ideological preferences without clear competitive and defense strategies attached to them. Over the next five years, China will spend overall about U.S.$300 billion on science and technology initiatives in areas such as biopharmacy, bioengineering, bioagriculture, and biomanufacturing (Cohen 2013).

There certainly may be some dire consequences associated with the misuse of these *brave new world technologies* but, from someone who

has studied the rise and fall of innovation in China, I cannot help but notice similarities in the closing off of China from the rest of the world to America's decision to reject vital biotechnological research. Much of this rejection is due to a primary misunderstanding of the technology and lack of scientific knowledge of the public. One would hope that the West does not give up its knowledge and practice of these technologies even as we see China take a strong and firm hand toward embracing them in its technological future. One can only hope that such technologies will be used for good and not evil and make policies and actions that guard against that in the first place rather than stick our heads in the proverbial sand.

CHAPTER 3

Economic Perspective on Innovation in China

Eight years have passed, this time I come to see that Shenzhen, Zhuhai and some other localities have undergone rapid development. It is really out of my expectations. After seeing all this, I've got enhanced confidence.

—Deng Xiaopeng, from his talks in Shenzhen during a visit in January 1992[1]

Innovation and Its Effects on Economic Development in China—Shenzhen

After years of double-digit growth and receiving kudos worldwide for having survived the economic recession that hit the Western economies so hard, the Chinese economy had slowed a bit after 2009. At the time of writing this book, the annual growth rate—once 10 percent and higher—is now around 7 percent. This has not necessarily been too bad for China, but it does point out that China is not immune from the economic interdependence of the world economy. It also points out the importance of taking into account the size when examining growth rates. Of course, in October 2014, the country took on the role as the largest economy in the world. But, now that China is the largest economy in the world, it must naturally slow in growth (small things have more room to expand on, after all). On a per capita basis, however, China still has room to grow, and it can be argued that the way in which the per capita gross domestic product (GDP) of the country can grow is via investments in innovation-based businesses and government activities. As pointed out by Lundvall (2007), traditionally economists believed that the only way to increase national competiveness was to reduce nominal wages or devalue

the national currency.[2] Today, we better understand the role of productivity and innovation in propelling economic development. A strong economy also supports innovative activities such that there is a re-enforcing cyclical relationship between economic prosperity and innovation.

This relationship demonstrates a progression in economic growth as spurred by innovation, and in China, the region of Shenzhen is a great model of how innovations can help create something from nothing. Prior to the reforms of the late 1970s, Shenzhen was a rural field in which the major economic activity was rice cultivation. Due to its proximity to the areas that traditionally had seen foreign involvement, namely, Hong Kong, Macau, and mainland Guangzhou, Deng Xiaopeng initially chose the area for unique consideration as a Special Economic Zone (SEZ). These SEZ designations allowed the Chinese to experiment with economic reforms without exposing the masses to the potentially disturbing influences. At first, innovation was in the introduction of foreign technologies and business processes to the Chinese setting. Thus began the creation of what has been termed the *world's manufacturer* as foreign companies, spurred at first by the low wages and government incentives, formed cooperative relationships with Chinese firms to set up factories for creating and exporting products. Prior to China's induction into the World Trade Organization in 2001, the business environment was not for the faint of heart. All foreigners were required to have a Chinese partner (harkening to the Canton system of Imperial China's trading in the port city of Guangzhou referred to as *single port commerce system*), which established the monopoly of the Cohong.[3]

Economic Factors and Innovation—Toward a National Innovation System

This chapter explores the impact of China's economic policies and structure on the propensity toward innovation in the country. Certainly, the opening up of some aspects of the Chinese economy in 1970 by Deng Xiaopeng's economic and trade reforms have helped in this regard. These reforms spurred the influx of foreign technologies that increased the technological capabilities of the country via foreign direct investments (FDI). The combination of economic, political, and cultural factors such as

educational institutions creates an underlying milieu of innovation that is often characterized as a National Innovation System (NIS). This concept is introduced in the chapter so that we can use it to explore in more detail within subsequent chapters the effects of each subsystem element.

What Is Economics?

Economics is the science of understanding the allocation and utilization of resources within a human system or society like a country or a home (as in *home economics*). We often call economics the *dismal science* because most of its predictions in the long run relate to the notion that there is no free lunch in the universe. That is, resources are limited and utilization of resources ultimately results in *decreasing returns to scale*. The classic example used in undergrad classes is that the utility or enjoyment of the first beer one drinks will always be greater than the next and so on until the utility may become negative (by the middle of the night or the next morning). This might also be equated with the notion in the physical sciences of entropy—the idea that the universe is constantly moving toward a state of chaos and disorder. The prediction in the end is always that the economy or universe will eventually peter out. This is the classical assertion in economics that resources are ultimately scarce.

How Does Economics Relate to Innovation?

One aspect of human action that can overcome these natural tendencies toward decreasing utilities and entropy is innovation and the nurturing of new and creative ideas. In fact, economists in the modern world moved beyond physical assets and resources and began to study the less finite and discrete implications of knowledge and information in a world of computers and information superhighway networks. Modern economists such as Paul Romer and Kenneth Arrow pointed to the importance of technology and innovation for driving economic prosperity rather than being a side effect of more fundamental economic factors—such as resources, labor, and capital.

As such, in this chapter, I look at innovation in China using the generic systems model from a national economic perspective. Here,

the concept of the NIS is important and relates to the generic systems model of innovation. For example, Lundvall discussed the notion of the NIS with the firm as the center of the system interacting with other firms and the knowledge infrastructure. He states that "to explain international differences in these respects we need to include a wider setting including the national education systems, labour markets (sic), financial markets, intellectual property rights, competition in product markets and welfare regimes" (2007, 102). As you can see, these are fundamental to the different perspectives used in this book where I discuss the effects of education, legal aspects, and culture on innovation propensities in upcoming chapters.

Notion of NIS

The concept of NIS has originally been linked to Fredrich List, who studied the catching-up abilities of emerging economies (1841). However, many scholars credit Christopher Freeman on his study of the emergence of Japanese innovation and the effect that had on its economy (1982). As Lundvall points out, NIS is essentially a tool that helps us understand innovation as a learning process that involves knowledge and its development (2007).

As such, our generic systems model of innovation combined with the capital framework is helpful—although this is by no means a complete picture. Nevertheless, it does enable us to categorize and make sense of what is happening over time in terms of innovation at the national level.

Table 3.1 shows the general elements of the generic systems model of innovation from the economics perspective. This perspective might include both government and private sector needs. I deal more with government issues in the next chapter on the political perspective. However, it is clear that any perspective will be influenced by, and depends upon, various actors. In the parlance of *actors* introduced in Chapter 1, we would refer to government actors as influencers in the economic perspective.

Boeing and Sandner (2011) conducted a comprehensive study of the NIS of China and delineated the key organizations for the process into categories first proposed by Joseph Schumpeter. The importance of each organization type and the policies that may affect their actions (covered

Table 3.1 Generic systems model of innovation from the economic perspective

Perspective	Needs	Actors
Economic	Profit Employment Increased standard of living	Firms-imitators Adaptors Complementors Pioneers Consumers
Money	**Organization**	**Outputs**
Profit motivation R&D investments	Manufacturing—traditional focus in China of lowering cost Reverse engineering Leapfrogging	Products and services

Table 3.2 Key players and their importance pre- and post- the MLP-2020 indigenous innovation implementation and policies toward success

	Domestic				Foreign
	Imitators	**Adaptors**	**Complementors**	**Pioneers**	**Pioneers**
Preplan	High	Medium	Medium	Low	High (Tech imports, FDI, R&D)
Postplan	Low	High	High	High	Medium (FDI, R&D)
Tax policies	−	+	+	+	
Procurement law	−	+	+	+	−
Intellectual property rights (IPR)	−	+	+	+	+/−
Standard setting				+/−	−

(+) indicates a positive effect of policy; (−) indicates a negative effect of policy.
Source: Boeing and Sandner (2011).

more in Chapter 5) are reproduced in Table 3.2. In general, imitators are plentiful and, in fact, useful during the developing stage of a country (such as for China before the medium and long-term plan [MLP] 2020) but become less useful as true proactive innovation becomes necessary for higher valued economic development. The reliance on foreign

technologies, though never completely waned in any globally integrated country (including the United States), should diminish and adaptors, complementors, and particularly pioneers will become increasingly important. While this was a conceptual framework for understanding changes as the MLP-2020 is implemented, recent evidence suggests the framework to be valid (Boeing 2014; Boeing, Mueller, and Sandner 2015).

Needs

The primary need emanating from the economic perspective of the model is economic prosperity. As mentioned, since the economic opening up of China's borders it has grown exponentially in terms of economic development. Some of this growth initially happened because of increased international trade and FDI, which accounted for a high of 6.2 percent of GDP in 1993 and 3.8 percent in 2013 (WorldBank 2015). However, such trade-based economies can only sustain so much of an increase in the standard of living. As China became more prosperous, its companies became richer and their employees eventually better paid—as demand for more skilled labor increased, so did the ability of such workers to demand more pay and benefits. This might be referred to as the virtuous cycle of economic development. As the economy grows, profits increase and so does the overall standard of living of the country. However, much of this depends upon the competitive and comparative advantage of the country and basic trade-based economies may not be able to sustain such growth—witness the agriculture-based export economies of Africa that seem to elude the virtuous cycle of economic development. In order to capture the benefits of increased trade, a country must move toward higher value-added activities that are also upstream in the chain of creation of a new product. This is depicted in Figure 3.1.

Innovation activities follow similar trends. While it is possible to innovate at the level of raw materials extraction and refinement, for example, the most pervasive and profit-oriented innovations are at the design level. Hence, at the time of writing, Apple, the Cupertino-based American company that designs the iPad and iPhone was one of the most profitable companies. Concurrently, while still a profitable company, one

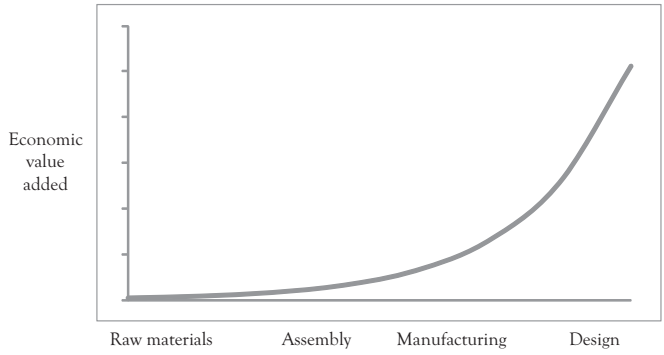


Figure 3.1 Relationship of commercial activity and economic value added

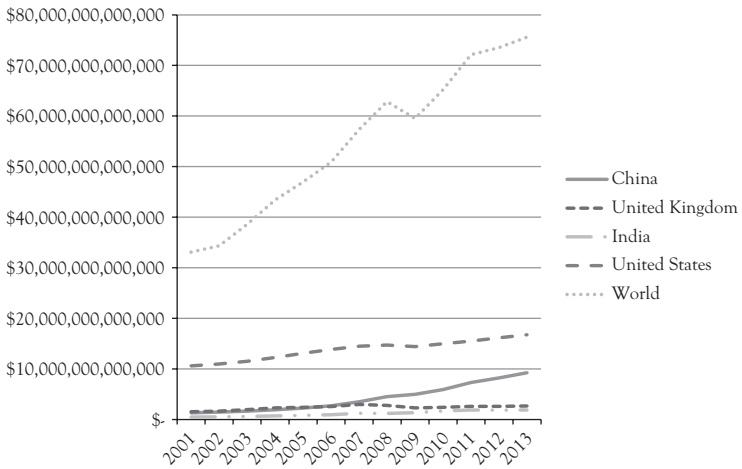


Figure 3.2 GDP in current U.S.$

Data Source: World development indicators from World Bank and Organization for Economic Co-operation and Development.

of Apple's manufacturing subcontractors, the Chinese-based *Foxconn*, was not considered as valuable. As of 2005, 75.1 percent of high-tech exports from China were of the assembly manufacturing type (Schaaper 2009).

As such, the basic needs of companies to make profit and consumer demands for more feature-laden and higher-end products drive the need to innovate at the economic level. The resulting growth in overall GDP has been noted and is shown in Figure 3.2.

Evidence in China suggests that companies are being driven more by profit motivation than ever before. Prereform Chinese enterprises were run by party bureaucrats and the legacy of the state-owned enterprise (SOEs) has been hard to shake. Research suggests that nonstate-controlled firms are more likely to perform better and have reduced agency costs than state-controlled firms after the opening up of China's economy (Li et al. 2012). Even today SOEs receive a bulk of government funding for enterprise-based R&D but are not very innovative. Focus on R&D by domestic Chinese firms has been in the information and communications technologies (ICT) industries. As of 2004, China became the largest exporter of ICT goods. In fact, Mainland China and Hong Kong had a combined 41 percent of the world market for ICT exports in 2012; though they also imported 29 percent for a net positive export of 12 percent or U.S.$181 billion (UNCTADStat 2012). I will discuss more on R&D in later chapters.

Actors

As we can see, from the economic perspective with a focus on the commercial aspects, there are two major actors in China. The first are the firms themselves, which are responsible for a large and growing share of R&D expenditure. They are the developers and facilitators of innovation in China. However, some of this impetus toward active R&D has been spawned by government initiatives toward building the indigenous innovation-based society. The Torch program, sponsored by the Ministry of Science and Technology, is one major government-initiated project that aims to support business enterprises via technology development. The Torch website lists four goals of the program:

1. To perfect the support system for high-tech industrialization, focusing on promoting indigenous innovation
2. To foster the growth of tech-based small and medium-sized enterprises and boost technological innovation in enterprises
3. To promote the development of innovation clusters and advance upgrades in high technologies

4. To mobilize innovative resources including capital, technology, and talent to reinforce support for innovation and industrialization (Torch 2015)

The site goes on to list nine tasks that might be accomplished to reach their goals, sounding very much like they are working toward an effective NIS:

1. Create favorable high-tech industrialization systems and mechanisms propitious to indigenous innovation.
2. Boost the capacity for independent innovation in tech-based companies.
3. Strengthen the construction of high-tech industrial bases.
4. Speed up the establishment of the fostering and tutorial system of technology companies.
5. Intensify the construction of a service system for innovation clusters.
6. Further improve the financing and investment system for high-tech industrialization.
7. Promote technology transfers and business-research cooperation.
8. Encourage the globalization of high-tech industries.[4]

Since 1988, the Torch program has helped set up science and technology industrial parks and business incubators that spend half of all R&D money in China and has led to revenues of an estimated 7 percent of China's GDP. Its focus is on precompetitive support for technological entrepreneurs in IT, biology, medicine, new materials, electromechanical integration, Environmental engineering, new energy, and low-carbon technologies and high-tech services. As of 2009, the number of projects awarded Torch funding doubled from around 2,500 to over 5,000 per year with a corresponding doubling of government investments.

Data on the activities of domestic and foreign private sector firms suggests that domestic companies are increasingly moving toward the development of new technological capabilities. Historically, we can view foreign companies as facilitators in this process. The case of ICT development in China presented later is demonstrative.

Recently, the magazine Fast Company listed the top 10 most innovative companies in China for 2014 (FastCompany 2014). Many of the companies were in the ICT industry with names like Xiaomi, Tencent, Geek, Baidu, YY, and Cootek. Another was the biotech company described in Chapter 2—Beijing Genomics Institute. Finally, there were Haier, the appliance manufacturing firm, China's Luxury Brands, a company dedicated to meeting the needs of the growing middle and upper class, and Phantom, a company that combines household appliances like lights with control systems for use with one's smartphone.

Customers themselves are influencers of innovation by providing demands for better products and services. There was once a time when foreign brands were considered superior in the minds of Chinese consumers (probably for good reasons). But that is changing, particularly in the ICT area where new companies such as Xiaomi and Tencent are changing the way Chinese consumers utilize cell phone and apps. A caveat comes from a *pendulum theory of history*, which points out the importance of a concept of *perspectives within perspectives*. The *pendulum theory of history* asserts that history repeats itself, and we are often doomed to relive past mistakes (or glories) if we do not recognize the patterns that create the recursive events. Harkening to the present day's drive toward indigenous innovation and lessening the influence of foreigners on China's matters, there was a similar drive in the past to label all things foreign as being *bad* or *evil*.

Figure 3.3 is from propaganda literature circulated in the Shanghai semimonthly circular Jilian huikan from June 15, 1937. It reads top-down from the right as follows:

> 1) Foreign mannerisms are superior! 2) The moon overseas is brighter! 3) Foreign farts are superior! 4) Foreign fish bones and fish heads are also superior! 5) What about being kicked around by foreign boots, is that a good thing? 6) Are foreign whips better? 7) Are foreign handguns superior? 8) And are foreign knives better? (Gerth 2003).

Hopefully history does not repeat itself in the present situation. Changes in personal income and the creation of some notion of property rights in China may help to ward off the trajectories of historical pressures à la Hegelian forces. As shown in Figure 3.4, individual consumption has

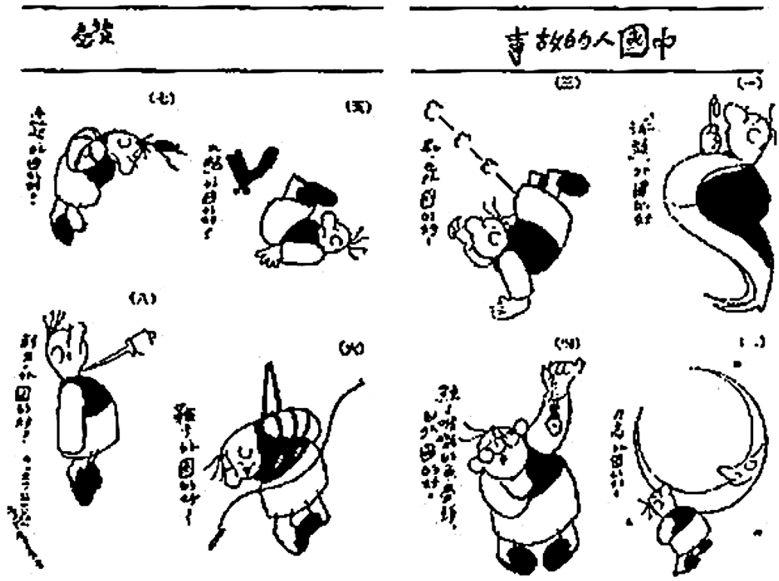


Figure 3.3 A spirit of self-reliance

Source: Gerth (2003), from Jilian huikan, 169.

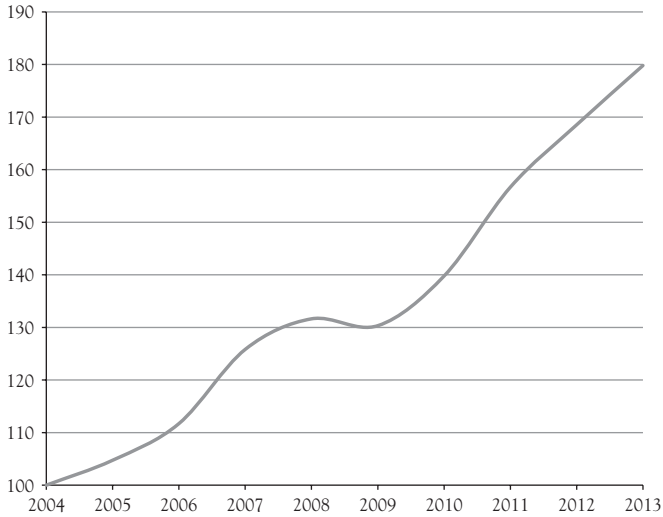


Figure 3.4 Consumer spending growth in China (100 = spending in 2004)

Data Source: United Nations.[5]

risen over the years of Chinese economic growth by about 80 percent over the past decade. However, it still represents a low percentage of the overall economy—36 percent of GDP in 2012—when compared to the rate of nearly double that in the United States (*The Economist* 2014). Some have criticized the Chinese consumers for not spending enough, which may be important to sustaining economic growth and stability in China.

Money

Table 3.3 depicts the economic focus of China over its history. We saw in Chapter 2 that China's society was primarily agrarian and economic activity including that related to the imperial prerogatives tended toward agrarian foci. Indeed, with over 1.4 billion mouths to feed, agriculture is still important today. However, economic organization has shifted toward the free market, knowledge-based society since Xiaopeng's initial reforms in the late 1970s. It is pretty much well known that the West made this shift after the Industrial Revolution travelling through the stages that China has seen first as an industrial manufacturing giant and now toward a knowledge-based innovation creator.

Organization

The traditional focus on organizing for innovation revolved around the government's need for national security as we will see in more detail in Chapter 4. However, as industrial motives have taken over and with the emergence over the past few decades of the behemoth of *China Inc.* and its massive capabilities in manufacturing, the shift has been toward industrial development. Over 70 percent of R&D expenditures were from business sources compared to similar data of about 60 percent in the United States. Some of this may be misleading given the high number of large companies still considered state-owned in the country (well over 200). However, it is also clear that most R&D conducted in China is of the experimental development type with less being done in basic and applied research, which has a greater share in the more traditionally developed economies of the United States and Japan.

Table 3.3 Some economic factors over time in China

	Era 1	Era 2	Era 3	Era 4	Future?
Factor	*Imperial China as an innovation-based society*	*Imperial China without innovation emphasis*	*Post-imperial China without innovation emphasis*	*Modern China without innovation emphasis*	*Modern China with innovation emphasis*
Economic organization	Agrarian	Agrarian	Focus on agriculture with some move toward industry	Industrial	Knowledge-based
FDI	Little relevance; some trade-related investments	Rejected outright	Turnkey operations accepted from Soviet Union; FDI not relevant	Initial FDI controlled through forced joint ventures; move toward full FDI	Toward free economy
Money supply or inflation	Based on copper supply	Based on copper supply	Based on silver; potential collapse in currency due to silver price increases in the 1930s	Legal tender pegged to U.S. dollar	Floating currency
GDP	Higher compared to West	Lower compared to West	Lower compared to West	On par with West; per capita GDP still lower	Largest and most valuable economy in the World?

This means that the primary method of organizing innovation in China is still focused on leveraging manufacturing skills. A typical scenario is the development of skills toward a specific technology with the aid of foreign technology and outside partners. The case of high-speed rail presented in Chapter 5 is a good example of this. Over time as skills are developed internally, the Chinese company might become completely independent and begin to offer its own products or services. These are often similar to the original foreign product but different enough to withstand the scrutiny of lawsuits based on IPR violations. Thus, the organizational concepts of reverse engineering, competitive espionage, and leapfrogging come to the forefront. As explored in Chapter 5, some Chinese companies are known to actively exploit the intellectual property of foreign competitors to gain a competitive advantage in the domestic market. In fact, I alluded in an early publication to an open policy of espionage, which is well accepted in China. There I pointed out the existence of a *spy guide* in the National Library of Beijing that purported to teach Chinese companies how to steal Western technologies (Gilley 1999; Johnson 2006).

A major aspect of innovation in China as well as economic development and prosperity is the unequal distribution and regional disparity in R&D expenditures and outcomes across China. In general, the Chinese provinces in the East are richer and more prosperous. This is reflected in the expenditures on R&D, which are greater in eastern provinces too. An exception is Shaanxi, which due to its strategic location was a military and defense location, and continues to be well funded on a per capita basis.

Figure 3.5 is an illustration of some important areas in which specific technological competencies have been developed. These various industrial clusters have shaped and characterized specific regions of China. Note that the industrialized clusters still primarily lie within the eastern coastline of the country.

Output

From the economic perspective, the major outputs of innovation activities are new products and services. Modern China is replete with examples of Chinese companies introducing new products and services in the

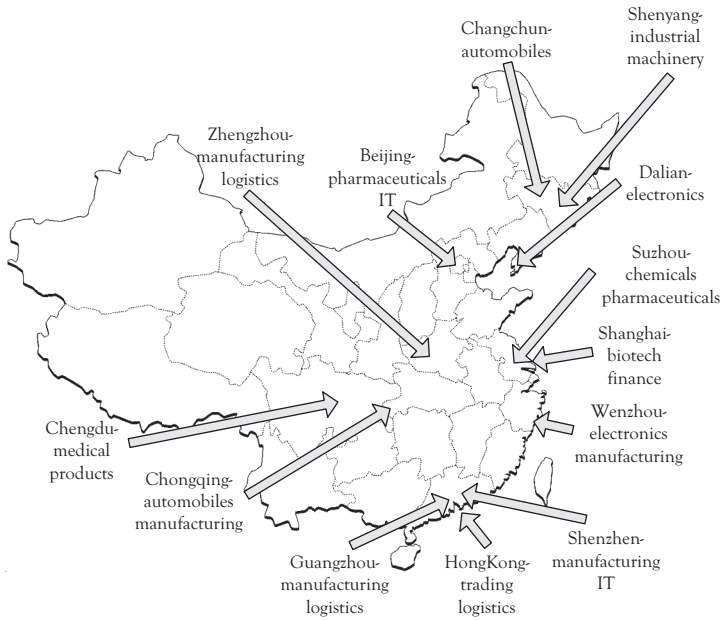


Figure 3.5 Important technology-business clusters within China

large domestic market. Most of these products like Xiaomi's low budget cell phones neither are radically innovative products nor are they typically based on high-end, state-of-the-art technologies. Rather strategies of imitation and *bottom of the pyramid* marketing in which products and services are designed to provide features needed for low income consumers at low cost have been hugely successful in penetrating the Chinese market. In the case of Xiaomi, the company sold about 19 million of its low cost smartphones in 2013 by utilizing flash sales of batches of phones—one batch at a time. To some extent this might represent an innovative marketing technique! It made most of its profit, however, from the revenue of software apps—about U.S.$5.2 billion worth.

CASE: ICT in China

Five of the ten most innovative companies in China on Fast Company's list for 2014 were in the ICT industry. This is further indication that the ICT industry, which would include telecommunications and smartphones as well as the Internet and web-based communications

technologies, is one of the largest and most pervasive in terms of industrial innovation efforts in China. Much of this impetus toward innovation stems from investments made by subcontractors of major foreign ICT players as well as massive investments by the Chinese government due to the strategic importance of these types of technologies.

Cell phone makers like Xiaomi and other larger electronics or IT product makers that have been around for longer like Huawei and Lenovo have been fairly successful in building brands that are internationally recognized with products that are sold throughout the world.

Over the course of one year (from 2011 to 2012), users of 3G cell phones in China doubled to over 23 million as fixed telephone use has dropped (to 27 million users in 2012) (National Bureau of Statistics 2013). The average penetration of Internet access in China was about 41 percent in 2012 compared to about 75 percent during the same year in the United States.[6] Figure 3.6 depicts Internet penetration by region in China. Again, regional disparities are prevalent—with only 8 of 31 regions having greater than 50 percent penetration.

Figure 3.7 shows the aggregate data on the percentage of population in China that had access to the Internet from 2002 up until 2012. It illustrates the classic S-curve and suggests that growth might have started

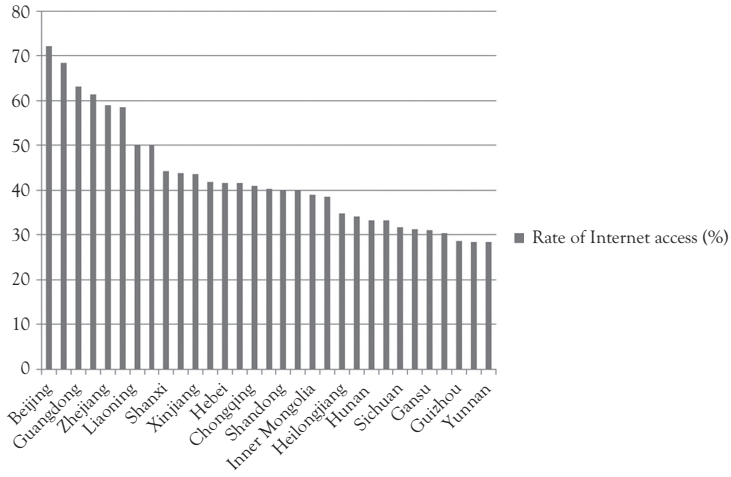


Figure 3.6 Internet access per region (2012)

Data Source: National Bureau of Statistics (2013).

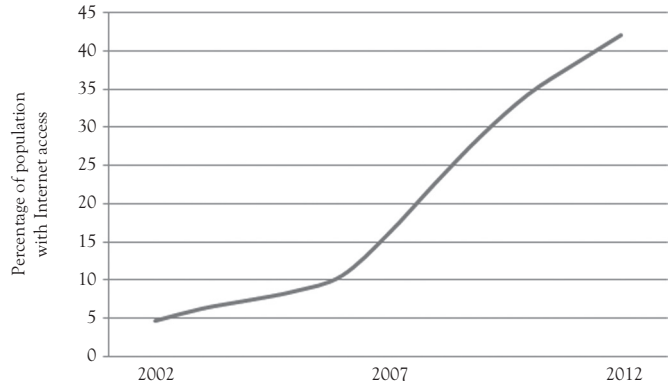


Figure 3.7 S-curve for Internet access in China over 10 years

tapering off in 2010. However, it is not unusual to see another S-curve materialize from the data or a newer and better technology come out that displaces the older technology and its S-curve. So this remains to be seen.

The three main players in the Chinese telecommunications industry are all linked to SOE-status, although in recent years they are being given more independence. The companies are China Telecom, China Mobile, and China Unicom. One particularly telling example of how innovation efforts sometimes work in China (or *not,* as is often the case) was the decree by the Chinese Communist Party to back away from the existing world standards at the time and work on developing a truly indigenous Chinese telecommunications standard. The result was the somewhat failed time division synchronous code division multiple access (TD-SCDMA), which was mandated to the three carriers. Eventually only China Mobile had to utilize it but by the time the 3G-based technology was deployed the world had already moved into 4G space. The fiasco is an example of how government should stay out of the process of innovation by mandating outcomes. The governments' role in the process is not that of a developer, which seemed the case with TD-SCDMA and an earlier attempt with Wireless Authentication and Privacy Infrastructure (WAPI), but rather that of a facilitator (via funding) and influencer (via regulatory structures). Attempting to control the process often leads to negative outcomes such as in the TD-SCDMA scenario.

One example of successful innovation that has been spurred by government efforts is the technology used to censor the Internet itself.

This is an example of technological innovation being linked to the goals of the Chinese government for a *harmonious* society. In the past, it was the technology associated with the bureaucracy of the emperor's reign that developed most rigorously. Today, given the unique characteristics of the Chinese environment, certain ICTs are associated with the Internet and communication protocols that are often focused on most. Still, much of this technology has once again originally come from abroad.

An example is the need for unique scripts to create Chinese writing using simple QWERTY-like keyboards. It helps that the written language or characters of Chinese languages are mostly similar across Chinese dialects and some other Asian languages in general despite differences in the spoken languages. As such, someone who speaks Mandarin in Beijing and cannot converse with someone who speaks Cantonese in Hong Kong may nevertheless engage in dialogue via the written word. However, this also helps in terms of censorship and the Chinese have been wildly successful at creating IP protocol technology that blocks or redirects and finds censored material. The result has been the Great Chinese Firewall (Zhongguo Weida Fanghuoqiang). It remains to be seen what effects this might have, however, on the overall innovation of the nation. Human beings ultimately require a certain level of free thinking and leeway in creativity to be radically and sustainably innovative.

CHAPTER 4

A Political Perspective on Innovation in China

Politics is war without bloodshed while war is politics with bloodshed.
—Mao Zedong

Government and Its Effects on Innovation

We have already seen some of the effects that government and political bodies can have on innovation. In general, such political organizations can have both positive and negative effects on the propensity toward innovation and successful innovation outcomes. However, as pointed out previously, the main role most successfully played by political actors is as enablers and influencers of innovation rather than developers. Thus, it is important to distinguish the role of actors from the political perspective. Scientists, engineers, and business development managers innovate—political bureaucrats do not (at least as a general rule).

This does not mean that public organizations do not play a role in the innovation process. Their influence can be substantial. However, historical evidence suggests that when bureaucrats try to manage the innovation process rather than support and build the framework within which innovation takes place, disastrous outcomes materialize. Mao's quote at the beginning of the chapter is instructive in that it suggests that the political perspective is a forceful and motivated one. Indeed the political perspective on innovation is meant to drive the process of innovation with respect to the needs of the political elite—that is, the ruling government—via its policies, laws, and sometimes outright instructions. All governments do this in different ways, very much as Tolstoy suggested that all governments censor but in different ways. Tax treatments and the funding of R&D are means that affect the propensity toward

innovation efforts related to the political environment. However, when companies innovate merely for the sake of gaining tax credits and not creating competitive advantage, the result is usually listless and useless outputs—often of low commercial and public value. Thus, the need for a commercial interest in the process of innovation is evident, particularly given the nature of our interests in this book, which is primarily about the commercial innovation of new technologies.

The role of government in terms of imitation versus (proactive) innovation was put forth by Mahmood and Rufin (2005), which demonstrated that the expected path of innovation is toward imitation for firms within countries far from the global technological state-of-the-art frontier. They state in their seminal paper that

> When a country is far from the technological frontier, the government can spur economic development through the centralization of economic and political control, but as the economy approaches the technological frontier, the government's role must change considerably, political and economic freedom being necessary. In addition, domestic business groups can act as substitutes for governmental intervention, and multinational corporations can supplement governmental efforts (Mahmood and Rufin 2005, 338).

Thus, their theory supports the propositions made in this book and of which empirical evidence demonstrates that government must take a supporting role and not an active developer role in proactive innovation. That is, the influence on innovation efforts must expand outward toward other entities or actors and allow them to emphasize innovation processes in order for a country to move toward the *technological frontier*—or in terms expressed already in this book, indigenous or proactive innovation. Of course, it is interesting that the title of Mahmood and Rufin's (2005) paper was "Government's Dilemma: The Role of Government in Imitation and Innovation." The authors were perhaps somewhat playing off the epigram from Professor Clayton Christensen's well-known book, *The Innovator's Dilemma*. However, what they actually meant by the dilemma was that government could spur innovation by centralizing economic and political interests but only at the level of imitation so

that efforts toward proactive innovation might be counterproductive, if not addressed as stated earlier. That is, a creative, higher level innovation requires a diversity of thoughts and ideas that are inimical to centralization efforts. Thus, the centralized planning activities of Mao's original efforts toward innovation were ideal for imitating Soviet innovations and Russian technology but failed when China was left on its own. The Great Leap Forward is testimony to the folly of that perspective. Millions of people died of famine in the name of transforming China from an agricultural society to an industrial one because no one wanted to admit that the *plans* were fallible. We will explore this kind of hierarchical model that pervades the education practices of the country in Chapter 6.

Ultimately, it is government that sets the stage for innovation at the national level, however. They do this by creating the incentives and putting in place the policies and laws that govern the processes through which ideas are transformed into products and services. Now we will take a look at how China has been doing that and how they might improve for better results. Table 4.1 shows the general elements of the generic systems model of innovation from the political perspective.

Needs

Many of the innovation outcomes we are interested in here are commercial in nature. That is, as we saw in Chapter 1, the output of innovation

Table 4.1 Generic systems model of innovation from the political perspective

Perspective	Needs	Actors
Political	National security Employment Self-sufficiency Indigenous innovation: MLP-2020	Government agencies: CAS, MOST, etc. SOEs
Money	**Organization**	**Outputs**
Government R&D spending: R&D funding R&D investments	Government support programs Government funding process "Mega projects versus peer review process"	Effect of Government Policy: Low output from SOEs Focus on quantity not quality

MOST, Ministry of Science and Technology; CAS, Chinese Academy of Sciences; SOEs, state-owned enterprises.

should be some sort of novel, creative product or service. There are other forms of innovation, however, that may not stem from commercial interests. These are driven by the public needs of society. The most prominent at the country level is the need for national security though for some countries and situations public health and general social well-being will also drive much of it. These technologies are intimately tied to the science and technology (S&T) infrastructure of a country and can have numerous spin-off benefits that do influence the commercial innovation environment. The cases of the Internet and the microwave oven are examples of technologies that began as U.S. military projects but had lasting influence on more general public interests. This is where China started its modern march toward technological innovation by first importing turnkey Soviet technologies that primarily had military applications; a notable example being nuclear technologies. China's initial efforts have been referred to as the "two bombs and a satellite" campaigns, which resulted in an atom bomb, a hydrogen bomb, and the "East Is Red No.1" satellite.

When it comes to national security interests in China today, specific sectors are the focus of indigenous efforts. As mentioned in Li et al., "the Chinese government explicitly states that it must maintain 'absolute control' over the following seven industries: defence, electricity production and distribution, petrochemical, telecommunication, coal, civil aviation, transportation, and shipping" (2012, 306). The idea is that China should be self-sufficient in many critically important areas. This appears to hearken back to the days of the Ming Empire but it is not unique among nations to see certain sectors as critically important to national interest. The changing attitude of government, however, can be used to follow the areas that will be deemed as *critically important*.

The Medium and Long Term S&T Strategic Plan (MLP-2020) adopted in 2006 represented the platform on which the government would make its National Innovation System stance. Sixteen special projects were identified of which three were deemed classified and not released to the public. The 13 projects listed were as follows:

1. Core electronic components, high-end general use chips and basic software products

2. Large-scale integrated circuit manufacturing equipment and techniques
3. New generation broadband wireless mobile communication networks
4. Advanced numeric-controlled machinery and basic manufacturing technology
5. Large-scale oil and gas exploration
6. Large advanced nuclear reactors
7. Water pollution control and treatment
8. Breeding new varieties of genetically modified organisms
9. Pharmaceutical innovation and development
10. Control and treatment of AIDS, hepatitis, and other major diseases
11. Large aircraft
12. High-definition earth observation system
13. Manned spaceflight and lunar probe programs (McGregor 2010)

Potential candidates for the three classified projects have been identified by Raska (2013, 2) as follows:

1. Shenguang Laser Project for Inertial Confinement Fusion—a controllable, sustained nuclear fusion reaction aided by an array of high-powered lasers
2. Second Generation Beidou Satellite Navigation System—which may significantly enhance [China's] global navigation, tracking, targeting capabilities, providing guidance for military vehicles, ballistic and cruise missiles, precision-guided munitions, as well as unmanned aerial vehicles
3. Hypersonic Vehicle Technology Project—hypersonic flight vehicle technologies such as hypersonic cruise vehicles capable of maneuvering at Mach 5 speeds (6,150+ km/h), and flying in near-space altitudes

As such, the needs for innovation at the national level have been clarified in the past and only continue to become increasingly important to the economic and social well-being of the country. As such, the necessity for better systems of innovation within China is paramount and likely to remain a national priority into the future.

Actors

The Communist's People's Party of China is a vast bureaucracy. Indeed, it is somewhat reminiscent of the old cleric bureaucracies of the imperial reigns of China's past. With some changes (e.g., there is no longer an absolute ruler), it is indication that "the more things change, the more they stay the same." In modern China, there are four branches of government:

1. The legislative level is embodied by the National People's Congress.
2. The executive level is embodied by the State Council.
3. The judicial level is embodied by the Supreme People's Court (I will talk more about it in Chapter 5) and the Supreme People's Procuratorate.
4. The military embodied by the People's Liberation Army (PLA).

Government power is hierarchical starting with the president in the highest position, followed by a vice president, and then the premier, and so on. This is illustrated in Figure 4.1. The fact that the 2006 MLP-2020

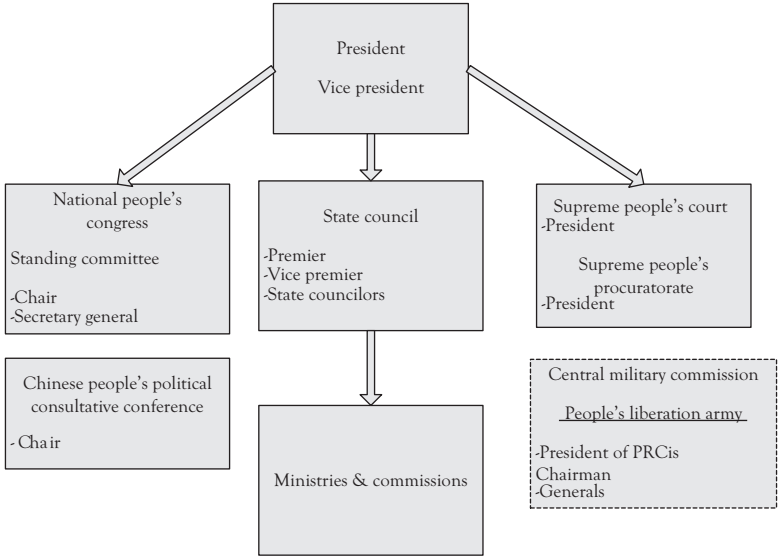


Figure 4.1 Structure of the Chinese national government (People's Republic of China [PRC])

was introduced by the then president Hu and continues its importance into the present government run under President Xi's helm is an indicator of China's commitment to indigenous innovation. Money for investments in S&T and national R&D efforts originally comes from the Ministry of Finance, which handles the nation budget, under the Supreme Council. From there flow other levels of government support. Notably, MOST is the government agency that develops and implements the national S&T strategy. It created and put forth the MLP-2020 and is charged with "drafting the National Basic Research Program, the National High-tech R&D Program and the S&T Enabling Program" (MOST 2015). It is organized into various departments. There was a time when it controlled all levels of R&D implementation but other organizations, mentioned in the following text, now play a greater part.

The CAS is an agency of the State Council of China with the mandate of governing over the scientific policies of the academic establishments in the sciences. A younger organization, the Chinese Academy of Engineering (CAE) also exists with the two being collectively called the *Two Academies*. The CAS also plays a significant role in funding and supporting S&T and R&D activities. It famously supported the early company originally called New Technology Developer Inc., which would go on to be renamed Legend and then finally Lenovo, with $25,000 of seed money (Osawa and Luk 2014).

Recently, after a visit by President Xi in July 2013, a *pioneer initiative* has been undertaken by CAS to enhance its abilities to help the country meet its goal of becoming an innovation-based economy. Specific actions are to:

1. "Restructure CAS institutes according to the following four categories in order to bring into fuller play its combined and interdisciplinary strength for major discovery and innovation—Centers for Excellence; Centers for Innovation; Centers of Big Science Facility; and, Institutes for special needs
2. Optimize scientific deployment by emphasizing the following five priorities:
    a. Strategic and major scientific issues and challenges (space science, earth and ocean exploration, big data, cloud computing, smart

technology, cyber-security, quantum communication technology, mobile internet, etc.),

b. Fundamental science, frontiers and interdisciplinary research (quantum science, brain sciences, superconducting materials, etc.),
c. Core technology for emerging industries (new energy, new materials, advanced manufacturing, etc.),
d. National safety & security,
e. Health and sustainable development.

3. Reform talent & personnel management system, for example, by introducing a tenure track system
4. Enhance the role and impact as a national scientific think-tank
5. Implement an open innovation strategy" (CAS 2014).

After more reforms in 2008, the Ministry of Industry and Information Technology and the National Development and Reform Commission emerged as important supporters of industrial R&D. China also has an organization similar to the U.S. National Science Foundation called the National Natural Science Foundation of China (NNSFC), which champions efforts toward peer-reviewed research.

Another major type of government-oriented actor in the innovation process within China is the SOE company. In China, being an SOE is likely to be the rule rather than the exception. Even in cases where a company may seem to be public it may indeed be related to some state entity. Haier, for example, is still considered an SOE despite it also being considered a public company. Evidence suggests that innovation at most SOEs is low; although, given the mandate of the MLP-2020 and the government push toward indigenous innovation, there is more emphasis on driving SOEs toward innovative efforts. Unfortunately, as in other cases, this leads to an abundance of low level activities being reported. This, of course, may make the company look good without actually doing anything worthwhile. Some people have put it more bluntly stating that until such companies are allowed to go bankrupt they will continue to be inefficient without much real innovation. Given the importance of stable employment and internal harmony to the Chinese government, the balance is in favor of the status quo.

Money

In 2011, 71 central government agencies provided funding for R&D, which totaled 73.73 billion RMB (about U.S.$12 billion) and accounted for 8.5 percent of gross domestic expenditure on R&D (GERD) (868.7 billion RMB) (Sun and Cao 2014). Total government contribution to GERD was about 21.7 percent or 189 billion RMB.

Other means by which government spurs innovation efforts are through tax relief and financial incentives for industry—discussed in more detail in Chapter 5. Expenditures on R&D were mostly from industrial players. In 2011, the government's overall contribution to GERD was 21.7 percent, which was about 8 percent less than Organisation for Economic Co-operation and Development (OECD) countries' averages. The contribution from industrial enterprises was 77.9 percent (Sun and Cao 2014).

Organization

The organization of modern R&D programs has evolved in the developed world toward the concept of the triple helix. Triple helix organization refers to the type of structure needed for today's complex R&D, which is multiorganizational and collaborative. It involves three major organization types: (1) government (with their public labs), (2) universities, and (3) industrial players (hence the triple helix imagery). China's evolution in R&D organization since the opening up of the country in 1978 has followed a similar pattern. Figure 4.2 shows the progress over time of the changing interactions and connections among the major players in China.[1]

A study that I conducted on the roles and resources of intermediate organizations suggested that the government should play a supportive role and not necessarily an active developer role in such organization (Johnson 2008). Indeed, recent evidence in China suggests the darker side of government playing too great a role with development issues in national innovation efforts. That is, government administrators should not decide who to fund and who not to fund. That, as we will see, often leads to corruption. Rather than that, letting the experts in any specific area select projects for funding via a blind peer-review mechanism is the more effective method, which is less prone to corruption.

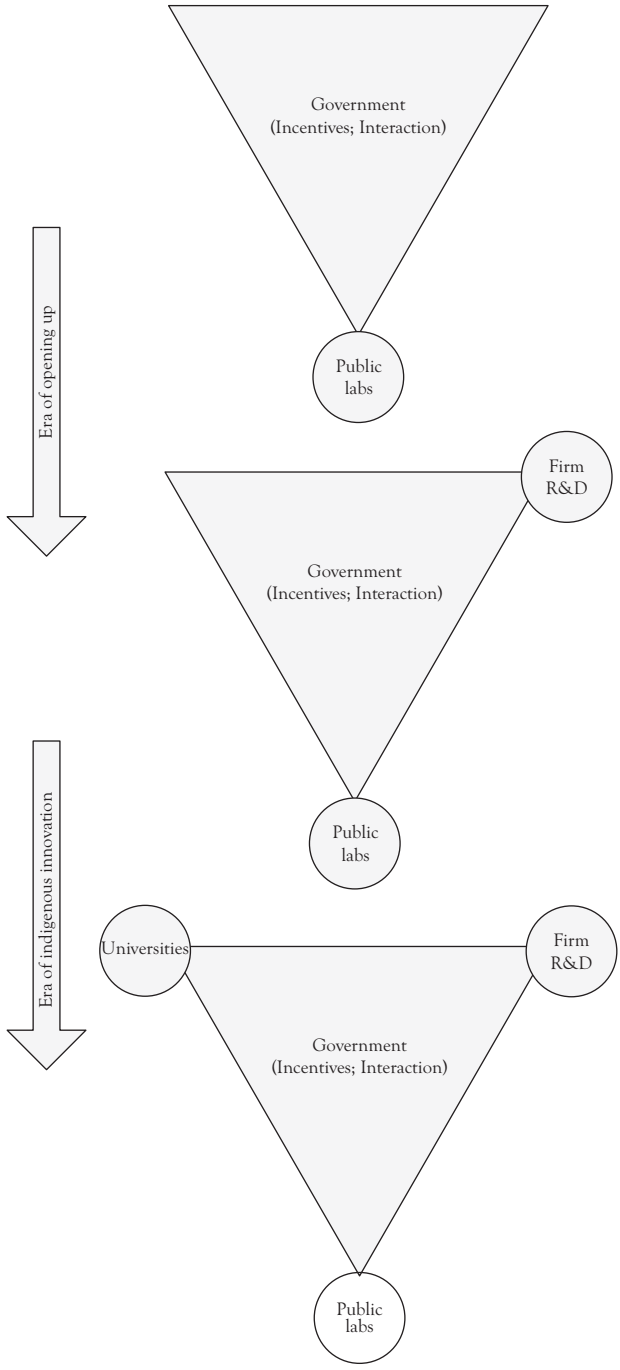


Figure 4.2 Organizational evolution in R&D toward the triple helix

Criticism from external evaluators of foreign lands, like me, is one thing. However, there has been some concern expressed by Chinese R&D insiders such as Zhejiang University Professor Liu Ming, who wrote a book in 2005 entitled *Critique of the Academic Evaluation System* (Ming 2005). He argued that the political system of China interferes too much with the academic and public research sector. I write more about the possible negative effects of the intimate ties of party members and university administration later in Chapter 6. With regard to government research funding and tax breaks for research, a study in 2008 found that greater than 70 percent of companies that were granted such status were, in fact, not technically eligible and did not pass the necessary requirements for funding (Springut, Schlaikjer, and Chen 2011). So much for anticorruption sentiments.

Recently, significant corruption in the funding of R&D by government has been found. Guangdong's provincial science department's deputy party secretary and 50 other party officials have been suspected of taking bribes from companies and researchers. Supposedly, millions of dollars of R&D subsidies and grants have been diverted into government officials' coffers. This may be typical of a system moving out of a stage where connections mean everything and real knowledge little. The good news is that such scandals are being discovered and lawsuits being brought forward, with the hope that such vast and despicable extortion, which is inimical to real innovation, will be mostly stamped out. For example, in June 2014, the former dean of Beijing University of Posts and Telecommunications' School of Computer Science and Technology was convicted of embezzling $110,000 and handed a 10-year prison term (Larson 2014). President Xi has made it one of his mandates to root out such wasteful corruption.

However, the threat of inefficient funding mechanisms is evident. More internal criticisms were made by Dr. Rao Yi and Dr. Shi Yigong, prominent scientists at Peking University and Tsinghua University, respectively. They wrote in 2010 that "to obtain major grants in China, it is an open secret that doing good research is not as important as schmoozing with powerful bureaucrats and their favorite experts" (Shi and Rao 2010). This is not necessarily too much different from funding activities within academia in the United States, where it helps to intermingle with

bureaucrats responsible for divvying up government grants. How can someone put trust in another unless they know them? We are all human and humans like to know who they are dealing with. However, crossing the line is evident when the only major criterion for awards is one's personal network (without regard to merit) and when such awards involve kick-backs and graft. Blind peer-reviewed systems help to maintain the integrity of a merit-based approach to funding even though it is not a panacea because in high-profile research it can be difficult to remain anonymous and track records are still important.

However, history in the West does suggest that it does indeed help to have a strong merit-based system that involves blind and double peer-review for funding potential projects. Unfortunately, China decided that bureaucratic mega-project funding, based on party officials' recommendations, would be used over the scientific community's peer review system. The NNSFC argued for a merit-based system that would better allocate funding and grants via peer-reviewed means. However, the bureaucrats associated mostly with MOST and CAE won out with their focus on megaprojects, re-enforcing the problem of connections being important to winning project funding. A favorite saying in the Chinese scientific community is "Small grants, big review; medium grants, small review; big grants, no review" (McGregor 2010). The unstated principle is that big grants go to those who are well-connected. If this continues, we will only see more examples of the waste discussed earlier and a collapse in the faith of the innovation-based society needed for a strong, future China.

Output

As alluded to throughout the chapter, the effect of government influence on R&D and proactive innovation in China has been mixed. While we will see in Chapter 5 that patent output has increased as government emphasis on innovation has increased, there has been heavy criticism that most of that output has been of low quality—particularly when examined at the SOE level. There is still a danger that the government's propensity toward external, quantity-based incentives will lead to perverse outcomes such that happened with the *great famine* after the Great Leap Forward. The pendulum theory of history rears its ugly head once again.

Case: Green Technologies—Solar and Wind Power in China

Green technologies of wind and solar power have had special focus in China, particularly given the political fallout that accompanies the huge air and water pollution issues of the nation. To some extent, this is a classic example of necessity driving the process of innovation.

According to a recent McKinsey report, China

> … will become the world's largest market for renewable-energy technology, and it already has some of the sector's biggest companies, providing critical components for the industry globally. Chinese companies not only enjoy calc advantages but also, in the case of solar, use new manufacturing techniques to improve the efficiency of solar panels. (Orr and Roth 2012)

The government helps to incentivize the ecofriendly business by providing feed-in tariffs, a means by which the companies can charge more for the energy generated by their technologies and thus encourage investment in renewable energy. Other means of providing incentives and legislation support the industry. It is a good example of how government can support the innovation process by influencing the developers and producers—in this case, for example, solar power technology companies. "China's total solar power supply up to 23 giga watts (GW), second only to Germany's 36 GW, and just 13 GW shy of the country's goal of having 35 GW of solar installed by 2015" (Topf 2014). It is even more impressive to see the market share that China has taken on over the past decade. See the following text.

China is home to some impressive solar energy companies. Suntech, the world's largest producer of solar panels, is located in Wuxi. Yingli Solar, another large solar panel manufacturer, is headquartered in Baoling. There are also Trina Solar, LDK Solar, JA Solar Holdings, and Hanwha SolarOne. Figure 4.3 shows the growth in solar cells for the major countries that have companies competing in the market. Since 2006, China has made impressive progress on capturing the largest share of the market.

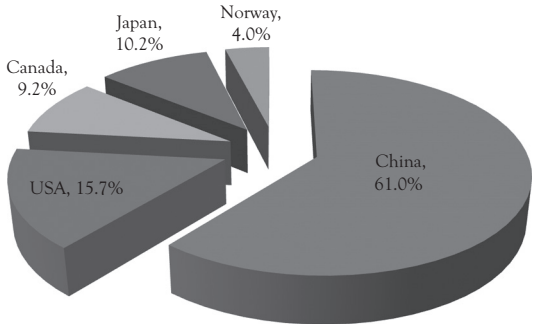


Figure 4.3 Share of solar cell market by country of top 15 manufacturers 2012

Data Source: (REN21 2013).

One problem with the solar industry in China is overcapacity and burgeoning debts. Suntech, for example, defaulted on its foreign debt in 2013.

Wind energy is another area of renewable energy production that China has embarked upon with heavy investment. One criticism is whether a focus on solar power generation would negatively influence wind power generation. China's wind and solar resources overlap—with the sunniest and windiest regions located in the north and west. According to Anders Hove, this would worsen "the situation for wind if the government decides to give solar priority" (Hove 2013).

There is one thing that is clear (pardon any pun) to any recent foreign traveler to China and that is the urgent need for more efficient energy usage and cleaning up the environment. A recent trip I took to Beijing revealed smog of catastrophic proportion. Outside a hotel I stayed at by the airport, it seemed as if there was a huge brush fire nearby. But that was not the case. One could not see much beyond a few hundred feet and even breathing could become uncomfortable. The only solace was an air-conditioned hotel room that probably only added to the problem. The Chinese are aware of this and as mentioned earlier there are political pressures being put forth to help turn the tide. A trade show at Dalian International Conference Center in 2014 exhibited art work that highlighted the growing health and social ills of air pollution. Figure 4.4 depicts some of the artwork. Some of the statements made in the art seemed highly

Figure 4.4 Collage of anonymous protest art in Dalian, 2014

politically charged for an exhibition in a Communist state but the government has been willing to accept some criticism in the past—just not any political organization in any form. The artists' identities, regardless, were not available.

Issues of quality and IP infringement are also at the forefront of renewable energy technologies in China. See Chapter 5 for the case of American Superconductor Corporation against Sinovel, China's largest wind turbine maker. It is highly regarded that any advantages that Chinese companies like Suntech amassed have stemmed from low cost innovations and the re-engineering of existing technologies (Zeng and Williamson 2007).

CHAPTER 5

Legal Perspective on Innovation in China

The more laws and order are made prominent, the more thieves and robbers there will be.

—Lao Tzu (Chinese Taoist Philosopher, founder of Taoism and author of *Tao Te Ching* [The Book of the Way], 600 BC to 531 BC)

Tricky issues of intellectual property rights (IPR) protection in China are legendary. This partly stems from the natural trajectory of a catch-up strategy that Chinese businesses have had to take in terms of technological development. As we have already seen in Chapter 4, Mahmood and Rufin (2005) demonstrated that the expected path of innovation is toward imitation for firms within countries far from the global technological state-of-the-art frontier. However, the government strategy of demanding foreign technologies for market access, utilized since the beginning of China's opening up, fits naturally with the *spy guide* in the National Library of Beijing mentioned in Chapter 3 (Gilley 1999; Johnson 2006).

But there is also a more innate influence (which is explored to some extent in Chapters 6 and 7). That is, there appears to be a natural tendency toward imitative practices in general for both Chinese culture and society. One interesting phrase for *innovation* in Mandarin, for example, is *Zhao Hu Lu Hua Piao*, which means draw a dipper with a gourd as a model or *to imitate*. In Chapter 6 on the educational perspective, I will discuss the natural tendency toward copying in learning how to read and write Chinese script. If imitation is the sincerest form of flattery then the

Chinese have shown great respect for the technology and innovation of others!

Recent years have witnessed changes to this phenomenon but the perception still exists such that even the MLP-2020 itself, as a call toward proactive innovation, was "considered by many international technology companies to be a blueprint for technology theft on a scale the world has never seen before" (McGregor 2010, 4). For China to achieve its MLP-2020 objectives to become an innovation-based society by 2020, however, it will need to continue its efforts to transform the legal system that protects the innovation process. The most pertinent aspect of that system is the IPR legal system often associated with patents and their application. However, patents are only one aspect of protecting innovation (and often valueless without strong enforcement and active management[1]). Table 5.1 shows the general elements of the generic systems model of innovation from the legal perspective.

The entire legal system can be seen to influence the propensity toward innovation. Innovative thought and invention stems from creative exercises that require freedom of expression and experimentation. It is no wonder that innovation-based societies tend to be associated with free speech democracies that have strong rules of law. Unfortunately, China's traditional legal system has been very much based on Rule of Man versus Rule of Law. This began when the Emperor of China was the *be all and end all* of *legal* disputes and continues today with the supremacy of the Communist Party.

Table 5.1 Generic systems model of innovation from the legal perspective

Perspective	Needs	Actors
Legal	World Trade Organization (WTO)/ Other World Standards Increased need for protection of domestic firms	Courts: three Levels Standards organizations
Money	**Organization**	**Outputs**
$ spent on enforcement Judgment awards	Rule of Man (versus Rule of Law) Patent/IPR filing process Patent/IPR enforcement process Trade secret process	Effect of IP policy on innovation propensity Data on low value patents

Needs

We have seen throughout the book that it is the innate needs of actors within a system that drive the propensity toward innovation. Ultimately, it is the ruling Communist Party that is in charge of legislating the laws of China. One of the motivators for someone to innovate is that they might profit from their innovation. Prior to the opening up of the Chinese economy, this would have been difficult as there was no concept of private property—all property ultimately belongs to the state and real property was *leased* to those who occupied the land. This creates a huge expropriation risk to any investor. Today, on average two million rural residents lose their land each year to expropriation when "local officials treat the concept of collective ownership of farmland as (to imply) state or national ownership" (Keliang and Prosterman 2012).

Even with the largest successful Initial Public Offering (IPO) of the Chinese behemoth e-commerce company, Alibaba (via a holding company), there is discussion about whether the Chinese government can and will expropriate the business (Chang 2014). Consensus suggests that they will not because of the ramification for foreign direct investment in China and the economy's health. However, there is precedence in some cases such as with Chinachem, though there appeared to be a good legal reasoning for that case (Chang 2014).

In general, the move toward greater legal protections for private property (including IP) was spawned by the inclusion of China in the WTO in 2001 as well as the need to adopt standards for other trade benchmarks, such the Agreement on Trade-Related Aspects of Intellectual Property Rights while at the same time protecting national security. However, the greatest move toward protection has come from the need to protect domestic firms themselves and also provide a competitive platform for domestic firms to compete globally. In fact, the unique characteristics of the Chinese system discussed later under the organization section has created a new era of patent trolling, which ironically has foreign companies having to defend themselves in Chinese courts regarding property infringements! For example, in 2012, Zhizhen Internet Technology Co. claimed its voice-recognition software used by 100 million users was infringed upon by Apple's Siri software. In 2014, Apple lost the infringement case

in a lower Chinese court but planned to bring the case to a higher court stating that Siri did not infringe on Zhizhen's technology. Despite that, the Cupertino-based company stated that it was willing to discuss a possible settlement with the Shanghai-based company (Reisinger 2014).

While the increasing focus on IPR protections in China seem to be leading to these kinds of backlashes on foreign competitors, it is also welcomed by those who have called for more stringent and enforced property laws in general.

Actors

As with other perspectives there are numerous actors that have some bearing on the innovation process from the legal perspective. In general, all of these actors are influencers rather than developers or facilitators. This is an important point because it suggests that the legal actors are never proactively engaged in innovation, although their actions and opinions can either help to enhance or decrease the propensity toward innovation. Laws by themselves do not innovate but they certainly can impede innovation (witness the case on biotech and stem cell laws in the United States) and support innovation (witness the need for strong IP laws).

For our purposes, we focus on the two most influential actors in the legal realm—the courts and the organizations mandated to support the IP system and other standards-based policies.

There are four levels of judicial order in the Chinese legal system. The highest level in China is the People's Supreme Court. The three lower level courts are the (1) High People's Court, (2) the Intermediate People's Court, and (3) the Basic People's Court. They follow similar rank in terms of local, regional, state, and national jurisdiction. As such every province has a High Court and most major cities have an Intermediate court. Usually, one basic court exists in each county. Many patent cases are taken up at the local level, which, as one could guess and we will see later, leads to some issues of alleged bias and potential corruption.

Standards organizations that have a major impact on IPR and innovation in China (besides the Chinese Communist Party [CCP]-set internal standards) are, as mentioned previously, the WTO and the World Intellectual Property Organization.

Money

The currency of the legal system with respect to innovation is the money spent on enforcement and the creation of industrial and technical standards. The judgment awards are also indicative of the way in which innovation can be affected by legal actions.

The monetary incentive to patent has been put forth by the Chinese government in a number of ways. Tax rates for businesses that are deemed a *High and New Technology Enterprise* are only 15 percent compared with 25 percent for a normal business. Tax credits of 150 percent are offered for corporate R&D efforts spawning a desire to focus on R&D expenditures and grow them—sometimes seemingly for the sole purpose of obtaining such credits. Beyond helping to fund research and support entrepreneurial endeavors such as the Torch program seen in Chapter 3, there are numerous government incentive plans particularly aimed at enticing higher amounts of patent applications. Awards of up to 500,000 RMB (U.S.$81,500) are given at the provincial level specifically for registering patents abroad, also known as *China Patents* (Prud'homme 2013). All of this has helped spur the enormous growth in S&T indicators in China, which the world has recently witnessed.

In terms of the disincentives of the IPR system, there are the typical judgments awarded in IP dispute cases. A major issue is that judgments usually involve only business activities that were done within China itself. That is, losses are only calculated by what could have been sold in China by the plaintiff if the infringement had not occurred. Calculating such damages is difficult and some companies have used strategies that allow them to skirt the law. For example, according to a U.S. Patent Office report

> … where a Chinese manufacturer produces infringing goods and both sells those goods within China and exports the goods to other countries, Chinese courts will only allow a successful rights holder to calculate damages based on those goods sold within China (that is, the rights holder cannot include those goods that were exported). (USPTO 2012, 8)

If damages cannot be determined by such methods as described earlier, they may be capped at 1 million RMB or about U.S.$156,000.

Overall, an analysis of the money aspects of the legal perspective on innovation in China suggests that a major incentive exists toward a focus on increasing innovation efforts by domestic Chinese firms. However, there is little to no incentive to invest (and perhaps major disincentives in terms of lessening the risks) from the foreign companies' perspective. That is, China is still fraught with difficulties for most foreign firms, and they must tread cautiously when navigating the Chinese high-tech business environment.

Organization

One peculiar trait on the Chinese patent process is that it is based on *first to apply* rather than *first to invent*, which is how it is done in the United States. Another trait is that for legal protection, the patent must be filed first in China before being filed elsewhere in the world. Finally, China's State Intellectual Property Office (SIPO) allows three types of patents: (1) invention, (2) utility, and (3) design-based.

Utility patents are used in many countries but not in the United States or United Kingdom, where they are seen as inferior in nature. Such patents cover

> … any new technical solution relating to a product's shape, structure, or a combination thereof, which is fit for practical use and entitles the patent holder to prevent others from making, selling, offering to sell, or importing the product covered by the patent. (USPTO 2012)

They grant protection for 10 years. In 2011, the patent applications profiles at SIPO by Chinese players were 26 percent invention, 39 percent UM, and 35 percent design patents, while U.S. players applied for 89 percent invention, 3 percent UM, and 8 percent design (Neumeyer 2013).

The biggest issue for utility patents is that they do not require an extensive review by the SIPO. The normally highly valued qualities of a patent—that is, novelty, usefulness, and nonobviousness—are not required to be demonstrated. This makes them easier and faster to obtain

and also harder to fight in court. The vast majority of such patents are granted to domestic players. Furthermore, the present system only allows domestic players to utilize a dual-filing strategy, where the applicant simultaneously files for both utility and invention patents (and thereby gains quick protection from the first application, until, and if, the longer invention patent is granted). Presently, foreign applicants must file for invention patents only.

The transparency and legal process of China has been criticized by foreign innovators. Effective patent systems that encourage true innovation require the following traits: transparency, certainty, fairness, impartiality, and consistency or integrity (USPTO 2012). As shown in Figure 5.1, these are similar to the fundamental aspects of the Rule of Law concept.

China's legal system is based on a type of civil law as opposed to the U.S. legal system, which is based on common law. This means precedence is not necessary in most cases and that leaves a lot of discretion in the hands of the judge. Traditional Chinese law has also held a Rule of Man stance thus creating questions of fairness and political interference in legal judgment. For example, bias toward the local jurisdictions and the use of *ex parte* communication, where the presiding judge may communicate exclusively with the local party, has been charged against some judgments.

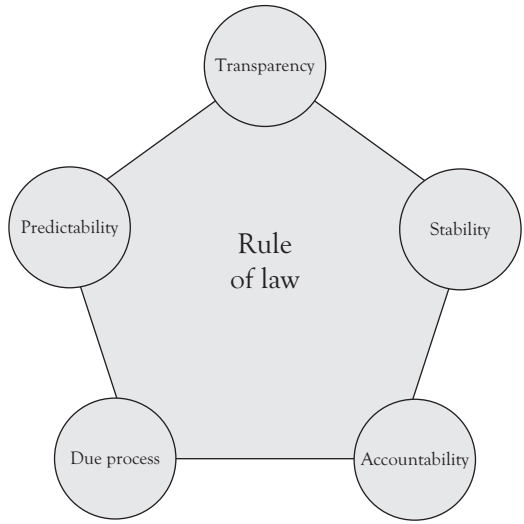


Figure 5.1 Major elements of the Rule of Law concept

In some cases, the recitation of the local party's argument has been used in explaining the final decision. The guidelines of the Supreme People's Court on the implementation of national IP strategy also noted that judges should "ensure the correct political direction … [and] also improve the enterprises' independent innovation capabilities." The notion of the correct political direction is an ambiguous and also foreboding expression that suggests that the cards may be stacked against those that would stand in the way of the national political will.

The lawsuit of American Superconductor Corporation (AMSC) against Sinovel (China's largest wind turbine maker) is instructive. AMSC alleged that Sinovel had violated its software copyright. Sinovel was AMSC's largest customer until it refused to accept shipment of components in 2011. A Hainan court dismissed AMSC's suit and Sinovel filed a counterclaim to the Beijing Arbitration Commission requesting compensation of 1.2 billion RMB (U.S.$191 million) for economic losses from breach of contract (PeoplesDaily 2012). The case treads on but AMSC claims that the lawsuit led to 500 lost jobs and has sued in the United States as well with criminal indictments being made against three individuals (DOJ 2013).

A Chinese businessman once told me that if the former phone division of the Finnish company Nokia was a Chinese company, then the government would have saved it and forbid sale of competitors when Apple gave Nokia a run for its money. Such intervention would be counter-productive to innovation because it leads to a focus on the steady-state and incremental innovation at best is the response. But incremental innovation by imitators requires that pioneers exist to create the first generation of an invention. Therefore, as a strategy moves more toward an indigenous innovation focus more policies that support pioneers are necessary, even to sustain basic imitators, adaptors, and complementors.[2]

Output

A particular concern that I have about the way IP law is working in China is that it appears to have led to patenting for the sake of patenting rather than true innovation. Because of tax incentives and government policies that encourage the practices, the applications for patents, and

particularly utility patents, have sky rocketed. According to Branstetter, Li, and Veloso (2013), Chinese businesses increased their R&D spending by 26.2 percent per year between 1996 and 2010, while the number of patents granted to Chinese inventors rose 4,628 percent between 1996 and 2010!

However, this is not necessarily an indication of underlying increases in innovative products and services. Boeing and Sandner (2011) utilized sophisticated methods to analyze patent value after breaking them into three categories of high, medium, and low value from 1990 to 2005. All types of patents had risen in China over that time period. In fact, high value patents rose 1150 percent (!) over five years (from just 2 in 2000 to 25 in 2005[3]). However, the majority of the new patents were of lower grade with 2,528 being considered medium value and 187,067 being of low value in 2005. More importantly, when Boeing and Sandner (2011) broke down the data in the years from 2003 to 2005, it was revealed that most of the applicants for the higher-valued patents were foreign firms; lower-valued applications were more likely to be submitted by domestic firms and universities.

The trend today continues toward a high number of low value-added patents. Furthermore, it appears that the focus on utility patents and systematic bias toward *first to file* rather than *first to invent* means that there is a pressure toward patent trolling in which companies exist to make money from litigation using patents rather than the use of patent to protect the process of innovation itself. This means that much of the innovation hype in China is turning out to be smoke and mirrors—at least in terms of the type of innovation that results in high-end breakthrough products and services. However, we should not scoff at the huge and admirable effort China has made toward becoming more innovative in general. It is likely to still lead to greater standards of living for the Chinese people. After all even lower grade patents may indicate some innovative progress. Some might argue, as the CCP might, that some waste in the system is the price to pay for moving forward. However, I do feel that, with regard to patenting, the Chinese are utilizing IPR protection as a sort of game to be played in trade strategies and nationalistic pride. As is typical with China, similar to perhaps the stereotype of Texas, everything is done *big*. The exponential growth in patenting and the indicators of science

and technology like R&D expenditures is impressive. However, as also pointed out recently by Prud'homme (2013), anyone interested in investing and entering China with technology and innovative products and services, particularly in conducting their due diligence of potential partners, needs to understand that what might look like intense innovation might just be a game of shells. *Caveat emptor*!

Case: High-Speed Rail

The case of high-speed rail (HSR) is typical of the Chinese ability to stealthily learn from foreign technologies and quickly develop low-cost capabilities to provide similar technologies but at more competitive prices. It is also one of the Chinese Government's major efforts toward indigenous innovation. HSR is defined as a system consisting of rolling stock and infrastructure that normally operate at a speed of at least 250 km/h on new tracks, or 200 km/h on existing (conventional) tracks (UIC 2010). The CCP government's goal is to have 16,000 km of HSR operating by 2020. In 2012, it had already over 9,000 km (about 10 percent of the entire railway system). The share of HSR over total railway lines is projected to be 13 percent. By 2014, China is estimated to have the world's longest HSR network with over 11,028 km of track in service, including the world's longest line, 2,298 km from Beijing to Guangzhou (Zhongxi 2013). This means that half of the HSR lines in the world (according to the length of rail) are now in China!

Of course, an accident that killed 40 people when two trains collided near Wenzhou in 2011 did create some reluctance in the public for HSR. The accident was blamed on a faulty signaling system and a lack of quality checks by the Ministry of Railways (*China Economic Review* 2012), creating questions regarding issues of quality and integrity in the system.

Growth in passenger traffic between 2008 and 2012 illustrates the typical S-curve of accelerated advancement as seen in Figure 5.2. What is interesting is that this growth did not make economic sense in that HSR is neither the cheapest nor the most efficient means of transporting people. In fact, according to Chinese statistics rail passengers in general represented only 5 percent of all passenger traffic in 2012,

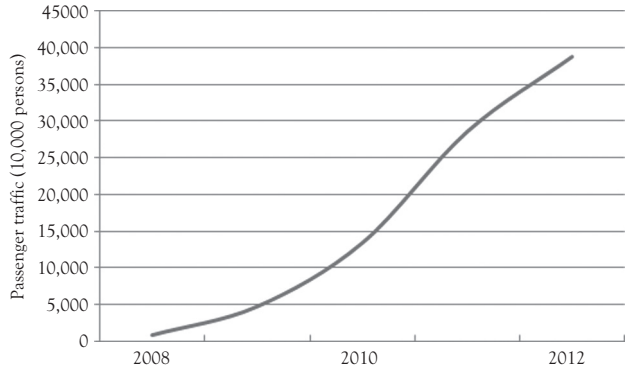


Figure 5.2 Growth in passenger traffic for HSR

Data Source: National Bureau of Statistics (2013).

down from 7.6 percent in 1996 (National Bureau of Statistics 2013). Since 1996, it is the highway that represents the means by which over 90 percent of people in China travel—so much for the days of the human-powered two wheel variety that Joseph Needham was used to when he fell in love with the country! (And the pollution that has come along with it.)

Chinese engineering has advanced to technological state-of-the-art designs. In fact, there was talk in the early 2010s that California, which only recently solidified the project to build a HSR between Los Angeles and San Francisco, might contract the Chinese to implement the project. As demonstrated in Chuang and Johnson, this building of national core competencies is somewhat related to the increase in world-class educational efforts by the Chinese (2011).

The first high-speed train to be built for China was the Shanghai Maglev Train by a joint venture of German companies, Siemens and ThyssenKrupp. It was built over two and a half years and cost about U.S.$1.5 billion. It has one line and two stops—one in Longyang Road and the other at Shanghai's Pudong International Airport. However, while maglev technology can achieve faster speeds its expense is too great for more conventional options so most high-speed trains use rolling tracks similar to Japan's famous bullet trains.

I had a chance to ride on the train. Figure 5.3 depicts a display that is in each car that shows the current speed of the train—in kilometers,

Figure 5.3 Speed indicator on the Shanghai Maglev train

of course! Figure 5.4 is a picture of me with the train in Pudong. Since that first ride I have travelled on other less speedy trains, but nevertheless impressive, like the CRH380A, which can travel at speeds up to 236 miles (about 393 km) per hour. The train terminals themselves are intriguing feats of engineering with their grand sizes and efficient organization.

Nevertheless, the Chinese have made no bones about the fact that they have utilized foreign technologies to get to where they are today. China South Locomotive and Rolling Stock Industry (Group) Corp. (CSR) has stated that "China's railway industry produced this new generation of high-speed train sets by learning and systematically compiling

Figure 5.4 The author beside the Maglev train in 2005

and reinnovating foreign high-speed train technology" (Shirouzu 2010). But, the German and Japanese companies from whom CSR and others learned the initial technology still see the leapfrogging as a sign of IPR infringement. *Caveat venditor*![4]

CHAPTER 6

Educational Perspective on Innovation in China

Give me a child until he is seven and I will give you the man.
—Jesuit proverb on education

As mentioned in Chapter 3, education is an important aspect of an effective National Innovation System (NIS). Furthermore, when developing the innovation capabilities of a nation, we are not just interested in higher education because (as alluded to in the opening quote) the personalities and aptitude of individuals are set early on in life. Thus, a base educational level for all citizens of a nation is necessary to sustain the progress in innovation endeavors not only from a development standpoint but also from the standpoint of the general public's ability to utilize the fruits of the innovation process. It is also important that people can understand the rudimentary aspects of innovation and demand progress and accountability. Of course, as discussed in this chapter, the types and levels of education will determine whether those capabilities will be of the high-end type or low-end type. Low-end capabilities are predicated on the ability to read and write and understand how to manipulate technology (i.e., merely use it). But as I argue via theories and models I developed over the last decade, obtaining high-end capabilities that can create new technologies and thus lead to innovation are predicated not only on advanced data and analytical ability (which the Chinese presently have in spades) but also a creative, critical-thinking ability (which is a lot harder to foster and maintain and for which present evidences overwhelmingly show that the Chinese lack—though other evidence suggests they may be heading in the right direction).

Despite the historical reverence for education in China (or perhaps because of it!), there was a time in the not so recent past when intellectual

Table 6.1 Generic systems model of innovation from the educational perspective

Perspective	Needs	Actors
Educational	Science, Technology, Engineering and Mathematical (STEM) capabilities Entrepreneurial capabilities General public need for technology-savvy consumers	Ministry of education Schools-universities; high schools, etc. Nongovernmental organizations (NGOs) focusing on education For profit schools
Money	**Organization**	**Outputs**
Spending on education R&D expenditures at universities	Chinese characteristics of education University links with business for innovation	Literacy rate % university-educated Number of graduates Quantity versus quality issues

pursuits were gazed upon with suspicion and resentment in the country. Education was stifled and the traditional respect for education and scholarly work that the Chinese had seemed distinguished. However, in these modern times, despite the fact that the Communist Party remains the government in power, without rival, education has made its comeback. Now, Chinese classrooms have replaced the four bearded Westerners (Marx, Engels, Lenin, and Stalin) who introduced the socialist concepts to the country that at the time was desperately searching for a philosophy that would fit its unique culture. In place of the four Glorious Comrades are the portraits of the four bearded Chinese sages allegedly responsible for the *Four Great Inventions* (of which Francis Bacon agreed, too)—namely, paper, the compass, printing, and gunpowder (Becker 2000, 202). Thus, in China, the link between education and invention (and eventually innovation) has been made. Table 6.1 depicts the general elements of the generic systems model of innovation from the educational perspective.

Needs

From an innovation viewpoint, a major need for the process of innovation is the underlying science and engineering competencies necessary to understand and manipulate technological development for inventing new

and better ways of doing things. As such, STEM capabilities are the focus in an innovation-based society. STEM skills are not enough, however, for innovation, which requires implementation of the inventions emanating from STEM capabilities. Business and implementation skills or entrepreneurial competencies are also necessary. Therefore, a focus on both STEM skills and entrepreneurial skills in the forms of creativity, financing, and marketing is necessary for proactive innovation.

The work on NIS also points out the importance in general of a well-informed and educated public (Freeman 1982; Lundvall 2007). For example, what good is a computer to society if the general public is technologically incompetent? What illiterate individual would buy a computer for doing work? Granted technologies can be simplified to the extent that the need for superior user competences is minimized but in general the greater the technological sophistication of the general public, the greater the adoption and use of technology, which has a positive effect on innovation acceptance and growth. Furthermore, sophisticated customers demand more sophisticated technologies, thus supporting proactive, radical innovation. As consumers become more technologically savvy, they demand more features in and capabilities from the technologies developed, which further influences innovation in a positive direction. Thus, the needs stemming from education (for innovation purposes) are self-reinforcing!

Actors

There is a vast number of actors who may have some meaningful effect on the education and learning of a nation. As mentioned earlier, the basic educational level of a nation will have some tangible influence on the technical abilities and propensities of the people to innovate. As such, when analyzing a nation's educational system and its effects on innovation, one really needs to start at the beginning and with the fundamentals. To that extent the topic of this chapter could fill an entire book, if done in detail. Here, I will cover the basic actors that have the mandate to move a country from merely technically literate to one in which its citizens can create and develop new technologies within its borders and be part of the sophisticated global network of technology developers. From the educational

perspective, this essentially includes government and nongovernment political agencies, as well as postsecondary, research-oriented schools.

The Chinese national government has stimulated the Chinese education system via funding and program incentives meant to spearhead the teaching of the Chinese people headed by the Ministry of Education. It appears to be taking the need to upgrade the system to heart as the first responsibility listed in its mission statement is the reform and development of China's educational system (MOE 2015).

There are over 2,400 universities and colleges in China (811 of which provide postgraduate education) and a huge number of students—befitting of the size of the country's population. However, few of these places of higher education meet the standards found in the better schools of North America, and the West in general. Still, the reputations of some have been established and are growing. Fudan University in Shanghai is often recognized as the *Harvard of China* while Tsinghua University in Beijing is given credit as the equivalent of Massachusetts Institute of Technology. Table 6.2 lists the other top seven universities of China—in total, the so-called *C9 League*. They are an alliance of the largest and oldest in the country and often seen as equivalent (in terms of analogy and not necessarily quality) to the Ivy League schools of the United States.

Other NGOs exist to help spur educational efforts. An example is the China Education Association for International Exchange (CEAIE),

Table 6.2 China's C9 League

University name	Founding year	Number of students	Location-province
Fudan University	1905	267,000	Shanghai
Harbin Institute of Technology	1920	37,700	Heilongjiang
Nanjing University	1902	22,100	Jiangsu
Peking University	1898	30,100	Beijing
Shanghai Jiao Tong University	1896	33,000	Shanghai
Tsinghua University	1911	26,700	Beijing
University of Science and Technology	1958	16,600	Anhui
Xi'an Jiao Tong University	1896	32,000	Shaanxi
Zhejiang University	1897	39,000	Zhejiang

Data Source: Grueber and Studt (2010).

which was founded as early as 1981 (CEAIE 2015). Its headquarters is located in Beijing. It is China's nationwide not-for-profit organization for conducting international educational exchanges and cooperation. They are now running a program called Education B2B, which is a newly established element of CEAIE starting in the year 2011. It is designed to help universities from China and universities and institutions abroad to build cooperative relationships with each other via a school-to-school networking opportunity. The targets of the program involve higher education, vocational education, continuing education, training programs, high school programs, and so on.

Similar to the huge market in the United States, there are a number of prominent private universities in China to cater to the large and burgeoning student population there. Many are affiliated with well-known Western Universities such as Jiaotong-Liverpool University in Suzhou, located about 100 kilometers west of Shanghai. China Europe International Business School is a cooperation of the Ministry of Commerce (formerly, the Ministry of Foreign Trade and Economic Cooperation) and the European Commission and is considered a not-for-profit joint venture. There is SIAS University in Zhengzhou with its pastel colored campus buildings, which was founded by entrepreneur Shawn Chen in partnership with Fort Hays State University of Kansas and is the first Chinese University to be entirely American-owned, but still fully accredited by the Ministry of Education. According to Huiqing Jin, founder and president of Anhui Sanlian University, China has always had private schools, going back to the days of Confucius and religion-based schools of Buddhist and Taoist sectors. He estimates that private universities account for 19.3 percent of higher education institutions with 19.7 percent of all matriculating university students (Jin 2014).

Money

Spending on education in general is slightly lower than more developed countries. China spent 4.28 percent of its GDP on education in 2012 compared with 5.6 percent in both the United States and the United Kingdom during the same year (HDR 2013; MOE 2013). Furthermore, the Ministry of Education in China states that this has been growing over

the years so that more and more investment is being made in general education. After all, the entire system supports about 14 million teachers in the nontertiary sector. This is about the population of the entire country of Cambodia! It compares with less than four million in the United States (NCES 2013). However, on a per capita basis there are still about the same number of teachers to students as in the United States.[1] It still is an incredibly large number of workers to manage via the Ministry of Education.

From the perspective of money invested in R&D activities, there seems to be less support for education and academic research. As reported earlier, R&D expenditures in China tend to be focused at the experimental development level, which is geared more toward industrial programs. Only 11 percent of the total R&D money spent in 2010 was spent at the academic level (Grueber and Studt 2010—Organisation for Economic Co-operation and Development data).

Organization

As pointed out in the case at the end of the chapter, the traditional Chinese education process is inimical to proactive innovation. As such, changes in the educational system have been necessary to change the attitude and capabilities of students toward more entrepreneurial forms. At Xi'an Jiaotong-Liverpool University, for example, a sort of student business incubator center supports students who create and run their own businesses. Most of these are traditional businesses and not high-tech endeavors, but the spirit and capabilities of entrepreneurship are developed there.

The case in the following text describes aspects of Chinese education inimical to innovation (or nonsupportive at best) in more detail but suffice it to state that the organization of education in China makes innovative thought difficult. To some extent the status quo is most comfortable for most people. Students like to have a solid rock-bed on which to rest their aspirations toward academic success (think the importance of grades and standard test scores to future success) and many professors and teachers also like the security of a black and white answer to every question. But, somewhat similar to the paradoxical response to the U.S. "No Child

Left Behind" program, this has led to an attitude toward education for *teaching to the test*. It has also resulted in ample cases of fraud and cheating (as was sometimes the case in traditional Chinese examinations where obsessed examiners would go to intense means to thwart cheating. One method was to have exams taken in a tiny boxed room with no means of bringing things in or out. Like one's own little academic prison!). In a 2010 survey, about 61 percent of student responders had observed academic cheating and 55.8 percent believed that their "college education did not encourage innovation" (Cheng 2010).

The paradox extends to the tension between the need for creativity in education and the need for conformance. Kwang and Smith (2004, 308) called this "The Paradox of Promoting Creativity in the Asian Classroom." It presents itself like this: Teachers (especially in the East) are encouraged to promote creativity in the classroom, yet many studies indicate that they do not like creative students.

From the same survey on academic cheating mentioned earlier, it was revealed that over 72 percent of students believed that these problems stemmed from the overlapping of administrative (i.e., communist government positions mixed with university administrative duties) and the teaching system at universities. In response, Zhang Ming, a professor at Renmin University of China, was quoted as stating that

> Some university principals worry that if they are deprived of their administrative title, people will have less respect for their universities. But they are actually talking about their own privileges that come along with their posts, such as using cars for free and taking first-class cabins on business trips. I haven't heard of any principal of a world-famous university losing his "dignity" because he does not hold a position in the government. (Kwang and Smith 2004)

Of course, this is what makes China somewhat unique—the intermingling of privilege with a sense of market freedom that results in a two-state system of political will. An example had been remarked to me once by a Chinese businessman when I was told that the elected mayor of a city was less important than the appointed city secretary, of course, a Chinese Communist Party member. The intimate ties of government

positions with nonpolitical social pursuits are a remnant of the old Communist approach of infiltration at all levels of society. As mentioned in Chapter 4, it is a characteristic of Chinese political and administrative life, which ultimately will have some negative effects on proactive innovation despite the good such perspectives can actually achieve in setting an initial direction—at first. Unfortunately, the classic problem of hoping for B but measuring and rewarding for A is at odds with the success of most Chinese programs (Kerr 1975). In the case of education, the hope is that Chinese students will be well prepared with the STEM capabilities and indeed they test well on that dimension (getting A), but the capabilities most needed for proactive innovation (i.e., B), on which an innovation-based society is supported, are not there (i.e., wanting B but getting A).

In 2008, I first developed a model with Professor Joseph Weiss at Bentley University linking education and innovation development over time. Figure 6.1 illustrates an updated version of the major elements of that model (Johnson and Weiss 2008).

Essentially, the model equates educational practices, which are hierarchical and cumulative, with the innovation outcomes likely to emanate

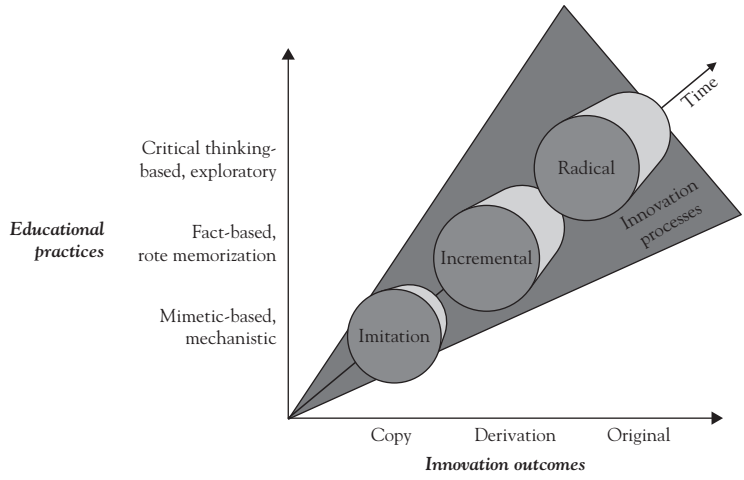


Figure 6.1 A model of innovation processes linking educational practices with innovation outcomes

Data Source: Johnson and Weiss (2008, 70).

from a disproportionate focus on each type of educational practice. The intermediate elements are the innovation processes that eventually lead to the innovation outcomes. The model draws on the well-known work of David Kolb and his hierarchical model of experiential learning. In Kolb's model, learning practices move cyclically in a pattern starting with concrete experience and moving through reflective observation, abstract conceptualization all the way toward active experimentation (Kolb 1984, 42).

Educational practices are hierarchical and cumulative in the sense that lower-level practices (like mimicking the teacher's practice) help to build higher-level skills such that they do not disappear entirely from the roster of skills needed for successful ascent to the *next level* despite being lower in value and grade. Thus, they are hierarchical in that they have levels of difficulty and cognitive abilities. They are cumulative in that they build on each other. Fact-based educational practices involve memorization and some greater level of cognitive understanding in terms of relationships of some facts to some other facts—but not all other facts! Finally the highest level of educational practices involves critical-thinking skills and the ability to design and implement experiments to test whether new ideas will actually work. This level is equivalent to Kolb's active experimentation level.

As depicted in Figure 6.1, the three general educational practices also underlie the innovation processes, which are also hierarchical in nature. Johnson and Weiss (2008) discuss the model's linkages in more detail, but here we can see that one can read the model by moving from the left axis across toward the innovation process to the right and then down to the bottom axis to determine the most likely type of innovation outcome. Thus, imitation innovation processes require basic mimetic skills resulting in copies of the original innovation. Consider design copies of other products like the infamous fake Rolex watch. Copying will be at low levels and likely to be of very low quality. As one moves toward fact-based education typical of basic level science and engineering programs, the innovation processes can build upon copying and also redesigning thus becoming incremental in nature and leading to derivations in the original designs and technologies. Imagine a newly designed cell phone with features specific to an emerging market as the Chinese company Xiaomi's

offerings. Finally, utilizing higher-level critical thinking and experimental practices can help move toward radical innovation processes, which are also higher-order cognitive learning processes similar to double loop learning (Argyris and Schön 1978)—the idea that you innovate on your innovation. The result is original innovative products similar to the goal of the Chinese toward achieving indigenous innovation. Think here—the iPhone.

Path dependency is also an important concept because what we know today depends on what we learned yesterday and the experiences that are predetermined by our past actions. This is the very notion of a calling or educational degree that takes years to build toward gaining adequate personal competence. We build up knowledge over time, and this creates what has been referred to in innovation management as *absorptive capacity*, the ability to absorb and understand new knowledge and utilize it (Cohen and Levinthal 1990). Path dependency and absorptive capacity re-enforce the idea that it takes time to build competencies to the level that allow for innovation, particularly at the radical level and with technologies and sciences that are complex and sophisticated.

This is covered by the time dimension shown in the model of Figure 6.1 and the idea that knowledge scope expands over time and as one moves toward the higher-level innovation processes.

What are the implications of the Johnson and Weiss model? Generally, the model suggests that if you simply want a population that can use technology you focus on imitative, lower level forms of education. If you want one that can imitate but also adapt upon the imitation, then a fact-based, intermediate level is necessary. But if you want a society with plenty of people who can create new knowledge and adapt it to practical means, then you need critical thinking skills and the highest level of education. Presently, China, and any country for that matter that achieves the mid-level fact-based skills leading to incremental innovation, can attempt to innovate based on the radical efforts of other countries. This is the very foundation of the "Designed in the USA; Made in China" phenomenon. This may also reinforce the notion of cost innovation as a strategy for economic success (Zeng and Williamson 2007). However, to do it on their own countries need to move to the higher levels of learning by focusing on developing critical thinking without losing the lower level skills.[2]

Problematically for the Chinese government (and any other government that wishes to maintain tight controls over substantial public affairs), however, is that the last level of innovation also requires freedom of thought and expression. For how can one be creative if one is in fear of retribution for one's creations? For China, the case of the Cultural Revolution was an expression of that hatred and fear. Thus, the implications of the Johnson and Weiss model are far reaching into various social and environmental spheres. The presently forming organization of innovation in China based on the educational perspective may be leading in the right direction (with a focus more on trying to create critical-thinking students), but the system appears to still have a while to go yet to reach this lofty goal.

Output

The present basic educational system in China is commendable for a country that only 40 years ago had to endure the Cultural Revolution. The literacy rate of the country (defined as the percentage of people ages 15 and above who have the ability to, "with understanding, read and write a short, simple statement on their everyday life") is about 95 percent (WorldBank 2014). Given the size of its population and recent development status, this compares well with that of the developed Western countries, which are reported to have 99 percent literacy. Like per capita GDP, China statistics are haunted by the vastness of the population and the disparity in regional development. Educating people in the western country-side is more difficult than in the highly urbanized eastern coast line. The lack of reliable information was evident in another example of regional disparity with the introduction and enforcement of the one-child program. After brutally enforcing the policy in the urban center, it was discovered that local officials had taken bribes and much of the rural population consisted of families with three or more children (Becker 2000, 372)!

I have had the chance to interact with a number of students from a number of universities throughout China. Although it is anecdotal, my impression over time is that the students are getting better. This is impressive, given the unique issues regarding educating such a large population and with such lofty goals as becoming an innovation-based society—only

a few decades after the country essentially rid itself of all academics! Chinese students, not necessarily dissimilar to Western students, still look for clues of what the professor deems important, but the seminars I have held at Jilin University, Xi'an Jiaotong-Liverpool University, and others suggest that they are getting more inquisitive and critical in their thinking abilities.

However, as in the case of the patent output of the country, there is concern that the system of education in China is setup in such a way as to emphasize quantity over quality.

Case: Chinese Education Practices and Their Effects on Innovation in China

The traditional Chinese education process is inimical to proactive innovation. A Chinese business person once told me that the highest form of art was imitation because of the tradition in China toward copying the masters of Chinese history. Another student I interviewed when studying the Chinese education system had stated the following, which seemed to sum up the experience of many Chinese-educated students:

> Copying, [is done] at the very beginning, especially for Chinese study because for Chinese we have special characters. It is not like English where you only learn 26 letters and you have different combinations …. For Chinese, we have each characters so you have to repeat a lot, copy a lot … like for one character you copy [it] 10 times in order to remember [it]. But later, … it could be in a different form. Like for example, if you are doing math problems … it is not every time that the teacher gives you a new type of exercise. It would … be like the same type of thing with different numbers and then you practice a lot and then in the exams, it could be that same type of question repeated! (Johnson 2006, 262)

Figure 6.2 is a picture of a student with his pen and ink as he practices learning how to write Chinese. Note also the identical uniforms the students are wearing. This type of repetition is used in early Western

Figure 6.2 Students at a primary school practicing calligraphy and learning to write Kanji

education, although not to the same extent. Even the phasing out of memorizing the old multiplication tables seems to be taking place in the West, while other techniques of learning math are put forth. Mimetic behavior is an essential aspect of most early learning; even in other species the young offspring learn from copying the behavior of their parents. But it is argued that to understand something one must go beyond merely copying it. Later in life Chinese students start to make the subtle connections that must be understood, at least tacitly, through experience. This is especially the case for a culture and language that are highly contextualized—such that the meaning is not expressed explicitly in daily communication. As such, the Chinese learning process is complex and paradoxical. Regardless, the preference for a strict master–student relationship in the culture, which emphasizes the subservient role of the student and amplifies the need for mimetic activities, is pervasive as I will explore more deeply in the next chapter on culture.

The idea that Asian students are better at math than their Western counterparts holds some validity but the idea that all Asian students are good at math is a false stereotype. Some theories suggest that the learning

of kanji and the nature of the ideographic or pictorial-based language helps to re-enforce the pattern recognition skills and logical structures of modern math. This may make it easier to learn when the learner is used to such processes. There is some relevance to the Johnson and Weiss model described previously. Knowing and using a character in writing requires mimetic and fact-based educational processes. Understanding context requires more.

The importance of education to the Chinese and the intense competition involved also helps because learning mathematics is made easier if one practices. That is, mathematical expressions are concepts that require doing to re-enforce the concepts rather than merely memorizing facts—but at the same time there are often and usually concrete answers to most mathematical problems (although not all, especially at the more advanced levels).

The importance of education to the Chinese is well recognized. Indeed, it is one of the great ironies that the study of Chinese education demonstrates such poor, disgusting treatment of intellectuals and educators in the country's recent history. This is in spite of the obvious reverence toward knowledge held by the Chinese in general. The *Cultural Revolution* was a bizarre indication of this perplexing conundrum. Regardless, today, as it had been in the times of the Imperial degrees, education is often seen as a way out of poverty and if a student is good enough and studies hard enough, he may find relief and great reward in his educational pursuits. An example of this hope for a better life is recounted in *The Diary of Ma Yan* about the life and dedication of a 13-year-old Chinese girl from Zhangjiashu—as her peasant family struggled to keep her in school (Haski 2004).

While China strives to reform an educational system that emphasizes conformity, the United States deals with the opposite spectrum. In the West, students are often encouraged to be creative without any rigorous, structured thinking underlying that creativity. Overly confident students in the United States, encouraged by parents who do not want them to self-doubt, often struggle with the *paradox of competency*—the idea that the less competent a person is, the more likely they believe they know things (because they are incompetent to know otherwise). A little knowledge is sometimes a dangerous thing and as Socrates, one of the wisest of

men in Western Antiquity, is believed to have stated, "I know one thing; and that is that I know nothing." What he meant by that is that we are all ignorant of things to some extent and that only a fool would believe that he knows everything there is to know and can stop questioning both the phenomenon and his own knowledge of it. Furthermore, the more we know, the more we discover that we do not know and hopefully that spurs further questioning and self-development. Thus, both questioning and self-questioning are important aspects of critical thinking and to that extent students and practitioners in both China and the United States must work on developing better skills.

CHAPTER 7

A Cultural Perspective on Innovation in China

I cannot help fearing that men may reach a point where they look on every new theory as a danger, every innovation as a toilsome trouble, every social advance as a first step toward revolution, and that they may absolutely refuse to move at all.

—Alexis de Tocqueville

Role and Influence of Chinese Cultural Aspects on Propensity Toward Innovation

The role of *Chinese culture* as a unique element in a Sino-centric society has yet to be fully applied to understanding its influence on the propensity toward innovation (in particular, proactive innovation) in China (Kash 2010).

Culture is an abstract concept representing the values, beliefs, and meaningful artifacts shared by a group within a society. Because values and beliefs and the artifacts used to do things are at the core of motivation and the propensity toward certain behaviors, it is reasonable to conclude that culture will have a material effect on the propensity toward innovation and creativity. In fact, it can be argued that culture (because it is described by the core values and beliefs of a society that shape the economic, political, legal, and educational perspectives) is the very foundation of a society's need to innovate. This is due to the strong and specific effects, we have seen in previous chapters, from each of these aspects or perspectives of a society—the economic, political, legal, and educational—on innovation propensity. Therefore one can see the causal effects of culture in the following depiction shown in Figure 7.1.

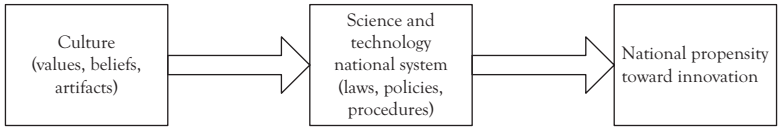


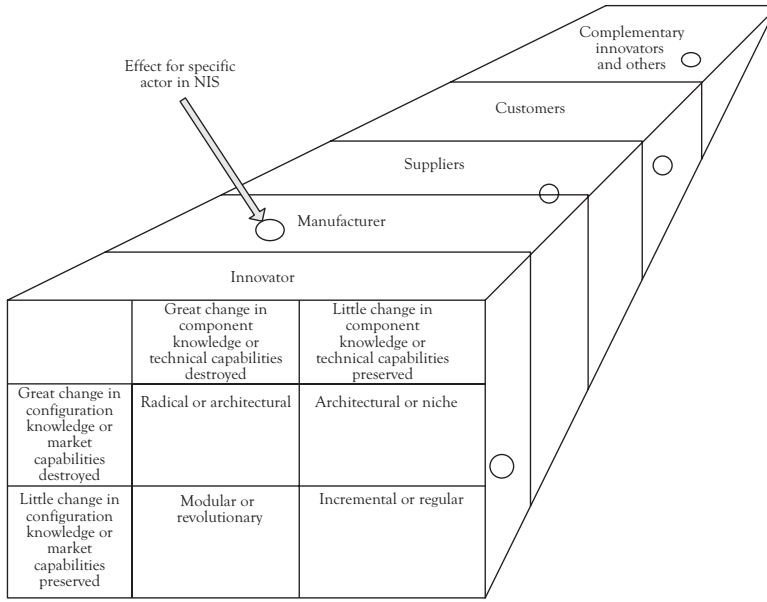
Figure 7.1 Culture as an important antecedent of factors that drive national-level innovation activities

Because culture is pervasive—that is, it lives deep within the beliefs of a group of people and is heavily contextual—it has the power to continually assert its effects despite outside changes. Thus, in this chapter we almost come full circle with Chapter 2 and the history of innovation in China by examining the underlying motivations (as well as demotivation) toward innovation that is so uniquely cultural.

Recalling Some Aspects of Innovation

Innovation is a concept that is contextual and situation specific—namely, it can mean different things to different people. As argued in Chapter 1, most people agree that *to innovate* means to introduce something that is new. However, the concepts of new and *new to whom* and what type of thing it is (i.e., a product, a process, an idea?) that is new is debatable. This makes the concept idiosyncratic. Recall that I defined innovation generally as the process of developing or enhancing a technological product or process for use in commercial or industrial organizations—thus, technological innovation. This is useful because we are interested in seeing whether national cultural traits are more or less associated with the underlying propensities of companies (and the individuals within them) toward innovating such industrial products or processes.

A useful typology is Afuah and Bahram's (1995) hypercube of innovation, which builds upon Abernathy, Clark, and Henderson models of technological innovation mentioned earlier (Abernathy and Clark 1985; Henderson and Clark 1990). The hypercube model, depicted in Figure 7.2, recognizes that today most technologies—the outputs of the innovation process—are multicomponent, complex systems and therefore stipulates that there are two important knowledge sets utilized for technological innovation. Component knowledge or concepts stipulate how specific components work. Architectural knowledge describes how



	Great change in component knowledge or technical capabilities destroyed	Little change in component knowledge or technical capabilities preserved
Great change in configuration knowledge or market capabilities destroyed	Radical or architectural	Architectural or niche
Little change in configuration knowledge or market capabilities preserved	Modular or revolutionary	Incremental or regular

Figure 7.2 Individual effects of innovation changes on specific actors

Source: Adapted from Afuah and Bahram's (1995) hypercube of innovation.

the components or concepts of the system link with one another. As such, incremental innovation—slight changes to existing components and systems linkages such that they are both enhanced—represents the weakest form of innovation (at least in terms of actual changes that take place). Radical innovation in which both component and architectural knowledge is destroyed to be replaced by a uniquely novel technology may be seen as the highest form of change. Christensen's Innovators Dilemma concept was built on the fact that most companies invest in incremental innovations, which focus on existing customers' needs and expectations while ignoring potentially disruptive innovations (Christensen 2000). The notion of core competencies may also apply as competencies that reinforce traditional linkages and concepts may create rigidities that are barriers to innovation (Leonard-Barton 1995).

The important aspect of Afuah and Bahram's model that extends on Abernathy—Clark—Henderson is that it takes into account each of the actors within the sociotechnical environment—such as suppliers, customers, and so on—each of whom has its own take on the *effects of the innovation*. As such, what may be an incremental innovation

to a supplier may be perceived as a radical innovation to its potential customer. These systems-level effects of technological innovation are important when contemplating the proclivity for a national cultural variable to affect propensity toward innovation. And this is especially important in a socially complex and intertwined country like China. For example, what may seem like a perfectly fine innovation at the firm level may not be acceptable at the market level. More concretely, something like radio frequency tags can be extremely useful for a firm to track its inventory, but the same technology can be seen as a threat by some customers if they sense that it might be used to violate their privacy. Alas, the concept of perspective is pervasive in the study of innovation.

Finally, David Teece's (1986) model of technology appropriability is also used later on in the chapter to help analyze the reaction toward innovation based on culture. Teece argued that successful innovation required not just a great new technology but also the complementary assets and appropriability regime that would allow the inventors to profit from their inventions. As such, the model described why the better mousetrap was not always successful and pointed out the complex nature of being successful with innovation.[1]

Table 7.1 mentions some general elements of the systems model of innovation from the cultural perspective.

Needs

There has been much research that discusses the idiosyncratic traits of Chinese culture. These usually focus on the unique philosophical perspectives

Table 7.1 Generic systems model of innovation from the cultural perspective

Perspective	Needs	Actors
Cultural	Harmony Political stability Traditionalism with change	Confucian actors Daoism
Money	**Organization**	**Outputs**
Currency of culture = Values	Changes in values with respect to innovation = "Innovation with Chinese Characteristics"	Decreasing importance of Guanxi

of Confucianism (Wang 1993) or Daoism (Li, Wang, and Fan 2011). Yau (1988) consolidated these Sino-philosophies based on Kluckhohn and Strodbeck's classification into the following categories: (1) man–nature orientation, (2) man-himself orientation, (3) relational orientation, (4) time orientation, and (5) personal activity orientation (1961). He argued that these traits affected the way marketing could be approached in the Chinese setting. Most of these studies suggest that Chinese culture is contextual and based on a strong in-group affiliation. Interestingly, the Chinese have been argued to strive toward harmony in nature and perhaps by the introduction of Western technologies have upset that balance—evidence of which is the rampant pollution in today's China. It is one of the most polluted countries in the world. The Earth Policy Institute ranked China number 1 with 2,395 million tons of CO_2 emission.

The needs for harmony, political stability, and traditionalism have been discussed or alluded to earlier. From the cultural perspective, they are all-encompassing and demonstrate unique attitudes toward innovation, as we will see in the following text.

Actors

From a cultural perspective, the actors of interest are the people within the society we are examining and are specifically characterized by the values that those people hold in general (as a society). In China, the number one value-laden aspect of its people is the tendency toward a need for harmony and respect for one's elders (traditionalism). This is typical of the Confucian philosophy. Taoist philosophy is also prevalent in Chinese culture. In many societies, there are numerous subgroups that may be examined by splitting up various subcultures. In the United States, for example, there is the subgroup of entrepreneurs in Silicon Valley who seem to hold different and acute values from their eastern New York counterparts or fellow mid-western U.S. citizens. Thus, at the national level things can get complicated. Indeed, all efforts at cultural attribution tend toward some degree of stereotype. However, there appears to be some truth even to stereotypes such that it can be useful to apply the cultural analysis at a general level.

For China, such cultural attributions can be applied to a greater extent than other nations because of the rather homogenous make-up of the Chinese population, which is about 92 percent Han. The rest of the population is made up of 55 ethnic minorities. Thus, the uniquely Chinese cultural characteristics are pervasive and well-ingrained within the country. The rest of the chapter will apply these characteristics to innovation propensity in China. However, I reiterate the warning that such application is made with the caveats to try to avoid excessive stereotypes and cultural biases. Also, one thing that research on cultures (both national and organizational) has pointed out over the years is that cultures and the values that underlie them can and do change over time—despite their integral and important nature, which is tied to the identity and action of the people they describe.

Organization

Cultural studies have examined the existence of general cultural dimensions across national cultures. Despite some criticisms of the methodologies and ontology of such studies, they have been influential. Geert Hofstede's five cultural dimensions of individualism and collectivism, power distance, masculinity and femininity, uncertainty avoidance, and long-term versus short-term orientation are well known (Hofstede 1980). Trompenaars and Hampden-Turner introduced several other cultural dimensions of similar design: universalism versus particularism, individualism versus communitarianism, neutral versus emotional, specific versus diffuse, achievement versus ascription, time (sequential, synchronous, present versus future), and inner-directed versus outer-directed (1997).

A rudimentary analysis presented in Tables 7.2 and 7.3 illustrates the fact that much of the technological innovation that has taken place in China is top directed. Recall how the original inventions from historical China were practical and often related to the needs of the bureaucratic elites (Johnson 2006; Landes 1998). This cultural tendency combined with historical and educational factors has resulted in a focus on imitative innovation strategies (Johnson and Weiss 2008). There has also been an early focus on government-directed science-based projects

(Liu and White 2001). With the continued importance of the MLP-2020 for indigenous innovation spawned by the Chinese Communist Party, the influence from the top is still pervasive. These approaches toward influencing innovation seem to fit well with the Confucian principles of filial piety, loyalty, and the importance of education while combining with Chinese *masculine* and risk-taking traits identified by Hofstede in a later study (see Table 7.2). These are the practical sides of the Chinese culture, which also help explain the productive and efficient nature of some Chinese efforts. To this extent, the Chinese are as pragmatic as the Americans—though perhaps with very different ways in organizing.

For example, while creativity may be downplayed—for instance, in the educational development of Chinese students (Kwang and Smith 2004)—a certain amount of rigor and focus is seen at play in Chinese innovation practices. As such, the Chinese have become well known for systems-level innovations. These may be seen to be modular in nature according to the model ala Afuah—Bahram—Abernathy—Clark—Henderson. For example, Zeng and Williamson defined this systems-level Chinese ability toward *cost innovation* as "the ability to apply scale-intensive technology to specialty products, transforming these businesses by dramatically reducing costs and prices and hence increasing volumes" (Zeng and Williamson 2007, 58).

There may be some truly impressive outcomes from such top-directed innovation—the development of nuclear technologies, for example. However, almost all of these developments were based on technologies that were originally conceived by foreign actors (first the Soviets and then the Western-based economies such as Germany and the United States). The less positive aspects of this type of innovation abound. State corruption and IP infringement on Chinese small and medium-sized enterprises (SMEs) are cases in point. For example, the Municipal Science and Technology Commission of Shanghai tried to pressure a local SME to create a joint venture with a local state-owned enterprise and were rebuffed by the company. The commission's response was to reverse engineer the company's product and sell their version under the same brand name! The unwitting company only found out about these actions after getting calls from duped customers for service on products the company did not actually sell them (Breznitz and Murphree 2011, 156).

Similar to Zeng and Williamson (2007), Breznitz and Murphree (2011) point out China's imminent position as a cost or network innovator stating that "currently, capabilities of ultra-mass-flexible production are unique to China" (16). This is an interesting point but may reflect the major problem for China and the world in general as it changes over time. The Breznitz and Murphree thesis makes sense while the world is a tightly networked supply *chain* but it also suggests that without changes China will always be dependent on foreign technologies. This would have tremendous effects on national and economic security for the country. It is also not entirely clear that the Chinese will or will not become more truly innovative in the near to mid-distant future. For example, as the rest of the world loses its dominance in some technologies due to the Chinese *outbidding them* (e.g., in high-speed train systems [Chuang and Johnson 2011]) the production of novel foreign technologies may be expected to decline. This is particularly true if you subscribe to the theory that product innovation is intimately tied to process innovation and early adopter usage (see Rogers 1995; Utterback 1994; von-Hippel 1988).

This can all be tied back to cultural predispositions discussed in Tables 7.2 and 7.3. The Chinese are well suited to intellectual ambitions but evidence and cultural bias suggests that most are comfortable when dealing with incremental or modular types of innovation. Unless changes are made in the very fabric of the culture, novel and unique innovation—what we have been calling indigenous innovation or *Chinese solutions for Chinese problems*—may be difficult to spawn.

Output

The preceding analysis via cultural orientations and their effects on innovation does not seem to support Chinese culture as amenable to proactive innovation. However, most large innovation-based companies today are multinational in nature. This is so in China. Therefore, it is difficult to postulate that any particular company will take on the trends of its domestic headquarters. Lenovo, which was IBM's computer hardware division (before Legend bought it and became Lenovo), is a multinational company by its very nature. As such, one way to overcome the potentially constrictive nature imposed by a dominant culture is to add diversity to

Table 7.2 Characteristics of China on several cultural dimensions and orientations

Cultural dimension and orientation	Characteristics
Confucianism	Confucianism is an ethical and philosophical system named after the philosopher Confucius. A major premise of the system is the maintenance of harmony in society and respect for one's elders, particularly the father. According to Peng, Moffett, and McAdam (2010), "Confucian philosophy greatly influences Chinese culture through teaching the 'values of filial piety, loyalty, righteousness, friendship and the importance of education' (Pang, Roberts, and Sutton 1998)."
Guanxi (connections)	Social relationships and harmony among them are important in traditional Confucianism. Guanxi is characterized by the network of close relationships a person develops over time. It "derives from the long-established Confucian heritage which draws on the underlying moral principles of hierarchy, interdependence, and reciprocity" (Huang and Rice 2012, 535; Kwang and Smith 2004)
Mianzi (face)	Mianzi is the concept that in order to keep social harmony people must have a way to save *face* in a conflict.
Renqing (reciprocity)	Renqing within the context of Guanxi is the concept that favors and positive in-group treatments will be returned sometime in the future. This creates balance in the Chinese societal order and re-enforces the ties developed via Guanxi networks.
Taoism	Taoist philosophy is an ancient system of practices and beliefs in which the concept of yin-yang is important. An essential aspect of the philosophy is balance in nature.
Hofstede's national cultural dimensions	
Individualism and collectivism	In individualist countries, people tend to look after themselves and their immediate families only and neglect the needs of society. In collectivist countries (or communitarianism under Trompenaars' model), people tend to feel strongly about their associations with a group and tend to avoid conflict with group ideals. China is generally seen as a collectivist society with tendencies toward in-group associations.
Power distance	This is the extent to which societal members accept that power is distributed unequally. In high power distance countries like China, people blindly obey superiors and hierarchical authority is important.
Masculinity	Masculinity described the dominance of social values such as success, money, and things. High masculine countries stress earnings, recognition, advancement, challenges, and wealth. High feminine countries emphasize caring for others and quality of life, cooperation, friendly atmospheres, employment security, and group decision making. China is fairly high on the masculinity scale.

(*Continued*)

Table 7.2 Characteristics of China on several cultural dimensions and orientations (Continued)

Cultural dimension and orientation	Characteristics
Uncertainty avoidance	Uncertainty avoidance is the tendency for people to feel threatened by ambiguous situations and to create beliefs and institutions to avoid such situations. Hofstede rated China as low on uncertainty avoidance, suggesting that the Chinese are comfortable with ambiguity in general.
Long- versus short-term orientation	China is described as a long-term oriented culture with a focus on future rewards usually achieved by perseverance and thrift.
Trompenaars' national cultural dimensions	
Universalism versus particularism	In universalistic cultures, ideas and practices can be applied everywhere. In particularistic cultures, circumstances dictate how ideas and practices apply China is a contextual culture and particularistic in nature.
Neutral versus emotional	In emotional cultures, emotions are expressed openly and naturally. The Chinese are somewhat neutral. While friendly, it is often difficult to tell whether they are happy or angry by facial and gestural clues.
Specific versus diffuse	In specific cultures, people are open and extroverted with a strong separation of work and personal life. In diffuse cultures, people are indirect and introverted, where one's work and private life is closely linked. In China, people live diffuse life styles with work and personal life intertwined.
Achievement versus ascription	Is one's status ascribed by one's position, for example, birth right, or do one's achievements determine a person's status in society? While there are cases of achievement helping advance a person in China (e.g., in traditional China, passing the imperial examinations), it is considered mostly an ascription-based society where family and position determine status—in modern China this is particular with respect to communist party affiliation.
Time (sequential, synchronous, present versus future)	Sequential means preferences for doing one thing at a time. Synchronous means preferences for multitasking Present versus future (and past) describes where a person puts his or her emphasis on the importance of time. In China there is a tendency to view all three time orientations simultaneously.
Inner-directed versus outer-directed	In inner-directed cultures, people believe in their control of the situation and outcomes. In outer-directed cultures, people believe in letting things take their own course. In China people are often fatalistic and thus outer-directed.

Sources: Pang, Roberts, and Sutton 1998; Peng, Moffett, and McAdam 2010.

Table 7.3 Effects on technological innovation of each cultural dimension and orientation

Cultural dimension and orientation	Predicted effects on technological innovation (using Afuah–Bahram–Abernathy–Clark–Henderson–Teece model)
Confucianism	Focus on innovation from the top (*Father Delivered Innovation*). When component knowledge is changed, there is a strong tendency to keep the architecture stable. Therefore, modular and incremental innovations are emphasized.
Guanxi (connections)	Networking is enhanced by Guanxi but at the expense of weak ties. Therefore, it reinforces existing ties and downplays innovation.
Mianzi (face)	Destroying knowledge risks losing *face*. Therefore, Mianzi negatively affects innovation efforts.
Renqing (reciprocity)	Renqing reinforces existing connection ties and therefore creates a strong tendency to keep the architecture stable and modular and incremental innovations emphasized.
Taoism	Wang argues that traditional explanations of nature given by the Dao have blocked the introduction of scientific theory in China's history (1993).
Hofstede's national cultural dimensions	
Individualism and collectivism	The myth of the inventor is that of *loner* but today most innovation in companies is complex and involves a multitude of innovators. Individualists are likely to break down both component and architectural knowledge. Collectivists are likely to innovate as a group enhancing architectural knowledge.
Power distance	Innovation is curtailed under high power distance because innovation is likely to be directed top-down in which case component and architectural are only enhanced.
Masculinity	High masculine cultures focus on achievement, which should promote innovation in general—if it is associated with commercial success. Teece's (1986) model of appropriability of technology is useful. Lacking complementary assets and given other factors discussed here, the Chinese might prefer leapfrogging technologies and industries in which fast next-to-market competitors profit most.
Uncertainty avoidance	In general, innovation requires risk and therefore risk adverse cultures are less likely to innovate. Cultures that are comfortable with ambiguity may be more inclined toward innovation. This factor suggests that the Chinese might be comfortable with messy innovation. However, several anecdotal evidence in the educational field suggest otherwise so this is likely to contextual in nature.

(*Continued*)

Table 7.3 Effects on technological innovation of each cultural dimension and orientation (Continued)

Cultural dimension and orientation	Predicted effects on technological innovation (using Afuah—Bahram—Abernathy—Clark—Henderson—Teece models)
Long- versus short-term orientation	It is generally believed that long-term or future thinking is associated with innovation. China, however, is often seen as one of the most traditionalist countries of the world. Despite the name, this cultural dimension is more about whether the society is Confucius-based and geared toward stability and harmony and thus mirrors the statements on Confucianism.
Trompenaars' national cultural dimensions	
Universalism versus particularism	This cultural variable is likely to exert its effects on innovation by affecting IP laws. Laws depend upon universal principles that apply to all. As such, particularistic societies often have a hard time supporting innovation. We have seen some evidences of this in Chapter 5.
Neutral versus emotional	Some aspects of creativity may be suppressed via neutral emotional expressions. Innovation can sometimes be spurred by emotions that are not supported by the present state. Similar to Mianzi, this will downplay innovation at the risk of an innovator being seen as an *outsider*.
Specific versus diffuse	Innovation and creativity sometimes require stepping back from our daily lives. While diffuse lifestyles reinforce the linkages in system actors, it may also reinforce traditional processes leading to incremental innovations at best. Therefore, specific cultures might be more amendable to innovation than diffuse cultures, of which China is considered.
Achievement versus ascription	Similar to power distance, ascription-based societies will not support bottom-up innovation and therefore do not motivate proactive innovation, in general.
Time (sequential, synchronous, present versus future)	The Chinese tendency to view all three time orientations simultaneously reinforces the traditionalist view and downplays radical innovation.
Inner-directed versus outer-directed	Innovation and creativity require self-motivation, which requires a sense that one has some control over one's destiny. Outer-directed cultures will tend to ignore innovation as change should come from without and not from within. This again seems to reinforce what might be called *Father-Delivered Innovation* programs. The Chinese government's five-year plans as the basis for future science and technology development are an example of such top-down orientations.

Sources: Teece 1986; Wang 1993.

the organization. Some very prominent scientists and entrepreneurs in the West have come from Chinese cultures, so there is anecdotal evidence that exposures to culture itself may not be overly constraining. However, it seems as if these individuals had to first break away from these cultures to move forward on their innovations.

My observations in the country (and what seems to be the case in the press and papers) are that the Chinese seem to be obsessed with networks. This may make sense in an economy and society that depends so greatly on connections to party members but the effects on innovative activity are less positive. While networks are important to innovation (witness the literature on geographic clusters of innovation) and strong ties have their place in securing funds, and so on, for entrepreneurs, the strength of weak ties to innovation cannot be underestimated. That is, innovation requires expansion and not contraction of the existing network for the innovator. Guanxi represents contraction. Networks like those provided by Guanxi can be important but when business becomes very competitive, they alone are not enough to sustain a relationship. One needs to bring real skills and competencies to the table and one never knows from which networks such things might come.

Despite the continued obsession with networking and prestige in China, there is the lessening in importance of Guanxi for conducting business. This move away from too much influence via Guanxi helps to avoid the dark side of the practice, which has been shown to link with acts of bribery and corruption as Chinese firms move toward increased networking and openness (Huang and Rice 2012).

While China continues to practice policies and processes that closely parallel traditional Confucian and Taoist principles (e.g., some may argue that there is little difference from a governmental perspective, between the imperial system or elite bureaucrats and the Communist party system or elite party members), it will prove difficult to move forward toward truly proactive and radical innovation within the country.

The fashion toward Confucian tendencies waxes and wanes somewhat in Sino-society but the fundamental nature of the philosophy is uniquely Chinese. It is noteworthy to pay heed to the words of the Western historian of China, J.K. Fairbank:

> … if we take this Confucian view of life in its social and political context, we will see that its esteem for age over youth, for the past over the present, for established authority over innovation has in fact provided one of the great historic answers to the problem of social stability. It has been the most successful of all systems of conservatism. (Fairbank 1992)

The good news is that this may reinforce the fact that we, as a global community, are interlinked and need each other to perform effectively in all types of innovative efforts. This is something I will explore while wrapping up the book in Chapter 8.

Case: Construction and Architecture in China

During the booming economic growth of the earlier 21st century, it was often said that the national bird of China was the *crane*—as in the mechanical one used to construct high rises. Today the construction business in China is worth well over U.S.$2 trillion. This includes both the construction of railways and buildings and other structures like dams and waterways. Some major projects being managed are the International Expo Center at Qinglong Lake in Beijing. Most innovation in construction is process related but the Chinese have shown, as with the case of high speed rail, that they can quickly build competencies to compete with foreign construction companies also most likely due to low cost innovation (Zeng and Williamson 2007).

Anyone who visits China will see that the architecture of some of its buildings is unique. China is a place where innovations in building designs and structures are evident. Architects Ma Yansong and Qun Dang of MAD Design, located in Beijing, are winning contracts for innovative buildings throughout the world. Figure 7.3 is a picture of one of their building projects entitled *Absolute Towers* and constructed in Mississauga, Ontario, Canada (which is incidentally where I grew up). It was built in 2009 and is quite the sight from a nearby highway. Some have supposedly nicknamed them the *Marilyn Monroe* due to their seductive shape.

Figure 7.4 is a picture of the campus of Zhejiang University located in Hangzhou, the famous lake city of eastern China. It has an almost

Figure 7.3 Beijing-based MAD design's buildings in Canada

Source: Jessica Davey.

futuristic appeal to it as if one were at the Epcot center in Disneyland, Florida. Unfortunately, the buildings' interior often leave a lot to be desired and the continual issue of emphasizing quantity over quality, in this case due to the need for rapid construction during the boom times, often haunts the industry in terms of code safety concerns.

A vivid visual example of the difference in safety codes in the West versus the East is seen in the pictures of Figures 7.5 and 7.6 taken in 2005 during my first trip to China. The site was the construction project

Figure 7.4 Zhejiang University in Hangzhou

Figure 7.5 New Century Square construction site, Shanghai (2005)

of a new square in Shanghai, now called New Century Square, across from the Howard Johnson hotel and along the Nanjing Pedestrian Road. You can see the pedestrian way in the background of Figure 7.5. What is interesting is the part of the picture that is circled. Figure 7.6 zooms in on what looks like a child being walked by its grandmother or mother in the construction site (sans helmets, of course!). The reason for this is that the construction workers lived on the job site with their families as can

Figure 7.6 New Century Square construction site, Shanghai (2005)—detail

Figure 7.7 China Pavilion at the Shanghai World Expo in 2010

be seen if one looks closely at Figure 7.5 at the barracks with laundry on the balcony.

Figure 7.7 depicts the Chinese pavilion at the World Expo held in 2010 at Shanghai. It is an example of architecture combining traditional Chinese geometry with the framing of a modern steel building.

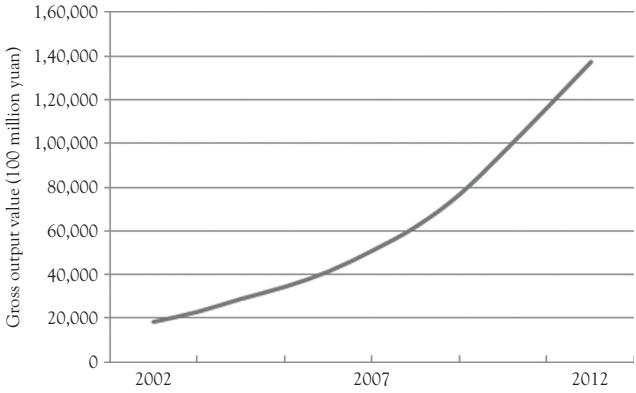


Figure 7.8 Value-add of the Chinese construction industry

Data Source: National Bureau of Statistics 2013.

As a proxy for expertise, Figure 7.8 shows that gross value added has increased exponentially over the past decade. This could be the beginning of a powerful S-curve, and it is evident that growth in the industry is great. Many construction projects are domestic in scope but there is also a growing industry of Chinese construction projects in foreign lands, particularly in African countries. For example, there are recent large undertakings such as an Algeria Al Oued residential project, a New Airport Project in Ghad, and a Communication Base Station Equipment Installation in Malaysia, among others (TUSIAD 2012).

Still, even the famous Bird's Nest stadium of the 2008 Beijing Olympic game was undertaken by Swiss firm Herzog & de Meuron Basel Ltd., with only consultant roles played by Chinese partners. The plight of Ai Weiwei, a prominent architect who acted as artistic consultant on the project, is of note. He was charged with tax fraud but he is also linked to antigovernment sentiments regarding corruption and poor safety codes in the construction industry. Thus, it is unclear what motives exist for the charges against him. Regardless, there are a number of talented architects in China and the industry appears to be primed to undergo the same leapfrogging process seen in the case of high-speed rail,—at least in parts of the world where inexpensive Chinese construction expertise is valued.

CHAPTER 8

Innovation as a Middle Way for the Middle Kingdom?

It doesn't matter whether a cat is white or black, as long as it catches mice.

—Deng Xiaoping

Needs and Actors—The Chinese as a Pragmatic People

The Chinese people (the epitome of which might be, Deng Xiaopeng, the reformer who may quite accurately be referred to as the father of modern China) are pragmatic in nature. Xiaopeng, in particular, while a hardline communist in many ways, was well known for his practical approach to prosperity, as appropriately phrased in the opening quote of the chapter. The saying is attributed to him but apparently was also a well-used phrase from the Sichuan region in which he grew up. For our purposes, it also provides a nice segue into the notion that provided the subtitle of the book—*The Tail of the Dragon*. The dragon has often been used as imagery when referring to China. It is a national imaginary animal originally symbolizing the emperor himself much like the regal lion symbolizes the monarchy of England. There is nothing new there. The tail, as I mentioned in the preface to the book, refers to the old saying about the "tail wagging the dog" (as opposed to the dog wagging its tail). This means a phenomenon that might be seen as small and insignificant is often the thing that makes the larger events happen—often in an irrational, *out of proportion* manner. The analogy, for our purposes, is that it is the need for innovation (symbolized by the tail of the dragon) that is making the dragon itself (representative of China) *get up and dance*. As we have seen in the previous seven chapters, this *dance* has been colorful, forceful, and noticeable, if not very graceful.

Obviously, in terms of the model used throughout the book, the needs and actors consist of the requirement for the betterment of the Chinese people in general. The National Innovation System of China will continue to be based on the premise that the general well-being of people is increased when innovation is the norm of a country. However, innovation for innovation sake or, worse, crying innovation when the *clothes* are the same old threads will not lead to economic prosperity and may actually result in the opposite effect.

Xiaopeng, in the famous quote that leads this chapter, was referring to the introduction of reforms that would make his country more prosperous without regard to ideological positions. Despite being communist at heart,[1] he was pragmatic and emphasized a "one country, two systems" approach to economic reform. However, it is difficult to stop the tail (of the cat in this case) from controlling the body when the tail becomes the be all and end all for every action. The question now is whether China represents a unique position in political economic reformation—truly a melding of two systems into a more efficient or effective one—or whether it is a "sheep dressed up as a wolf," in a perverse role-reversal. Or, perhaps I should use the imagery of the mouse that eats the cat!

Ultimately, we need to know from where comes and to where goes the money that helps drive the system—as pointed out in the system model.

Money—Where Is the Focus on Innovation?

Over the years that I have travelled to China, I have sometimes wondered whether the cultural orientations attributed to China, which I listed in Chapter 7 and have come from numerous studies about national culture, do indeed provide accurate descriptions of the Chinese. For example, I have travelled to over 40 countries so far in my career. In few places in the world have I witnessed some of the most selfish, individualistic behavior as I have in the country that most people regard as collectivist and socialist in nature. There are now famous Internet videos of such antics in China as the driver who blocked an entire row of traffic because he was upset at his son or the old man who climbed a bridge so that he could push off a younger potential suicide victim for "being selfish and

wasting everyone's time." Avarice, greed, and a love of material things are rampant in rich Chinese cities such as Shanghai and Beijing—so much so that it threatens the very fabric of the communist party. There is great fear that, as disparities between the rich and the poor in China become more and more evident, revolution is inevitable (as the pendulum theory of history rears its head again). This is what is behind the current drive by President Xi to stamp out (or at least be seen as if to stamp out) corruption and greed within the Chinese Communist Party (CCP). Money has become the new symbol of success in China. As if another fatalistic sign, Figure 8.1 is a picture of a display I saw at one of the companies that I visited in China in the late 2000s—a creative use of Chinese writing and the dollar sign!

However, as discussed in the next section on organization, this greed and love of money has led to many incidences of corruptions that threaten to undermine any real progress in indigenous innovation in China. The problem is that it is not an isolated issue and greed is not its only driver. Power and the ability to control direction are also at hand and

Figure 8.1 A new symbol of success in China

fabricated intricately within the motivation and support system of innovation in China—as demonstrated in many examples of earlier chapters. The problem with innovation is that it can create power but it does not necessarily allow the powerful to create it. In most cases where the powerful attempt to control the innovation process, they merely extinguish the flames of passion and need for true necessity that are the underlying engines of an effective innovation process. Prediction, which requires control, is difficult when trying to determine the next successful innovative product or service or technology. Control is useful for routine operational processes but the more one uses control in exploratory innovation processes, the more that leads to failure.

Organization—Implications of the Analysis of Innovation Efforts on Government Policy

Has China allowed the tail to wag the dragon? If corruption is held in check then the known incidences might just be considered a part of the inefficiencies of resource allocations in a large government system. However, depending on how vast it is, it may become an issue and a hallmark of government waste. If most money is being spent on true innovation and the education that underpins it, then that will be good for the country. However, if most is being wasted and siphoned off to corrupt and bloated officials, the effects may be disastrous. To me, it would be somewhat reminiscent of the story about the last Empress Dowager CiXi's Marble Boat—*permanently docked* at the Summer Palace near Beijing. Figure 8.2 shows a picture of the nonfloatable boat. The investment in the special project of the Empress Dowager is a classic example of the waste of public funds. When the coffers of China should have been put into funding a real navy, almost all of the country's money went into the unseaworthy boat!

With regard to innovation, we have seen throughout the book that there is increased attention being paid to innovation in China. The attention and the subsequent increase in activity have thus far been seen as mostly quantity-driven. As such, it appears as if innovation, if we are allowed to depict it as the tail of the dragon itself, is driving the behemoth body of the Chinese political and economic systems (i.e., the dragon).

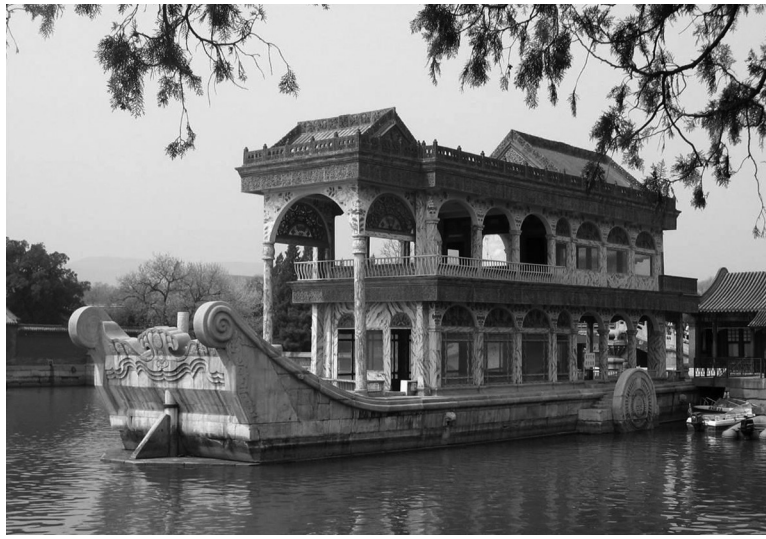


Figure 8.2 CiXi's marble boat

But, is the response to the legitimate call for building a more innovative nation a case of irrational, *out of proportion* quick fixes?

Recall the Boeing and Sander's study that was mentioned in Chapters 3 and 5, which found the disproportionate focus on low value patents in domestic innovation activities in China. In that paper, they concluded that endogenous innovation might fail China if its own standards are not successful and do not lead to increasing social welfare, productivity, and innovation within the country (2011, 27). A warning case in point was China's attempt to create its own wireless standard that failed and is indicative of the problems with top-down micromanagement of innovation activities (i.e., allowing the tail to wag the dragon). As much of the endogenous innovation efforts in China today are politically motivated and top-down, this is likely to lead to unintended consequences that may, in fact, decrease overall innovation in the future.

The government's role in innovation is to set the infrastructure and incentive system, and so on (e.g., via tax credits, seed funding, and legislation conducive to innovation), and then to let innovation actors manage themselves. Top-down direction and micromanaging is unlikely to lead to successful proactive and radical innovation. This was seen in the fight between those that argued for megaproject funding (political bureaucrats)

and those that argued for peer-review funding (e.g., scientists and actual innovators) after the recent MLP-2020 of China. Such behavior by the CCP suggests that endogenous innovation might be a pipe dream with more political spin than potentially impactful aspects.

Output—Is There a Middle Way? Or, Is China Doomed to Imitator Status?

A key question, however, is whether there is a *middle way* in the middle kingdom. That is, does some sort of hybrid exist that combines the philosophies of planned economies with free markets to solve the problems that *laissez faire* policies or control economies alone cannot tackle?

Economically, especially for a country considered to be communist, China seems to have done well so far. The combination of a free market combined with tight political control has been very effective from an economic standpoint—at least when the economy depended upon imitative technologies and low wage and cost advantages. But this success may not be the case when proactive innovation is necessary for sustainable economic growth.

As argued earlier, and should be clear from reading through the previous chapters, China's traditional and present economic, political, legal, educational, and cultural dimensions are well suited to playing off the strengths of foreign technologies. As the *world's manufacturer* and preeminent imitator of technologies, the country has become dependent on foreign technology. While the world is so intrinsically networked, such a position can in fact provide it with a unique competitive advantage as seen in the arguments of Zeng and Williamson (2007) and Breznitz and Murphree (2011). We have seen that history does seem to repeat itself in general cyclical ways, of which the German philosopher Georg Wilhelm Friedrich Hegel had suggested. As such, I would like to share the following quote, which seems to have come from today's headlines but was in fact printed in 1914: (Originally published in 1914 by the North-China Daily News and Herald, Shanghai.)

> It is often said that the peril of today is not the Chinese behind the gun, but the Chinese as the manufacturers of guns and of many

> other things, equally calling for the highest technical skill. It has been the fashion of newspaper writers dealing with the development of China to state that the danger to the West lies in the industrial expansion of China, and it is averred that the Chinese, with their cheap labour and keen aptitude for imitation, competing with the dear labour and the heavy cost of transportation of the West would certainly be able to beat the latter. (Wagel 1980, 291)

The fears of newspaper writers of the early 20th century did seem to come true (after a number of intervening years) but note primarily due to the factors listed in the quote. True innovation is more difficult to attain. The question remains—are the Chinese, as a nation, ready for proactive, self-initiated innovation?

Research suggests that there are effects on personal actions based on attitude toward and syntax regarding perspectives on time. For example, recent studies suggest that the Chinese save more money because their language does not have future-tensed words that may help one think about putting off actions until the future. As an example, in English we would state either—"I save money" or "I will save money" (and put off actually saving until later); in Chinese, there is only the expression—"I save money." According to Dy (1998), Confucius saw time like a river with "a definite past, but an indefinite future." As such, the notion of continuity over time may be somewhat unique to Chinese.

But there must be more to the story here. For innovation, it could go both ways. The expression—"I innovate" should be more closely associated with actual propensity to innovate than the expression—"I will innovate."[2] However, if language frames thinking in the way that academics like Wittgenstein and Chomsky might argue, then not being able to articulate a difference between past, present, and future might lead to a lack of innovation as expressed in the statement—"All things have been and will be, as everything changes, all stays the same." The river is at once flowing and yet in a state of permanence at the same time. Who would innovate under such conditions?

There is an example of such a temporal perspective at the War Memorial in Changchun, Jilin Province of China that describes the

Japanese invasion of China. The following is a quote of the English translation at the Memorial, which describes the invasion of the Manchurian region of China by Japan in the early 20th century. The last sentence is a perfect example of the translation issue of time with English and Chinese. As translated, one would expect that the occupation was still taking place. Again, time in Mandarin is *sensed* differently than in English:

> Never forget "September 18"—northeast to be occupied 14 years (historical fact display summary). The summary of displaying the historical facts of northeast to be occupied 14 years: The offspring will not forget, the 18th of September, 1931. It is the national humiliation day of Chinese nation. This day, Japanese invader mobilized "the 18th of September incident" keeping on plotting for a long time. From then on, the Northeast of China has become the Japan colony for 14 years.

Later there is an interesting parallel to the "Remember the Alamo" theme and also a reference to time past and present:

> *In order* to use history as reference, to be encouraging common people better, the leading comrades of the central authorities Jiang Zemin, Song Renqiong, Gu Mu wrote the inscriptions for the exhibition respectively. Comrade Jiang Zemin's epigraph was: "Don't forget '18th of September.'" Comrade Song Renqiong's epigraph was: "Don't forget the past sorrowful history to encourage descendant dedicated to the service of country." Gu Mu's epigraph was: "The past, if not forgotten, can serve as a guide for the future."

Is the Middle Way a Path to the Past?

Today there is extensive debate as to whether or not China is truly innovative. Some recent books and opinions seem to suggest that *copy-cat China* is no more. However, I cannot yet jump to that conclusion based on the evidences that have been presented. So far we have seen that China's environment, as a systemic whole, does not seem to support proactive

innovative propensities. However, does the general propensity of a population toward innovation matter? Could it be the case that China needs only a few innovators to meet its goals? Is this not the case for the United States, too?

Yes, but such a system is ideal for imitative innovation and explains the successes of China in the recent past. Ultimately, we may all be dependent on a small group of creative individuals to make the next big radical innovation. After all, most people are not innovative on a big scale although smaller levels of creativity can abound in societies that reward change and risk-taking. But that is the crux of the matter, is it not? The problem is that without a society that accepts and indeed rewards that small number of people who are creative and innovative, the rest of us (who are not so creative and innovative) will not benefit from the increases in productivity and standards of living that are the result of such creative and innovative thoughts and actions. Furthermore, it is rather difficult *a priori*, or before the fact, to determine from where those creative, innovative individuals will come. We must be open-minded about from where and whom the next big idea will come. The atrocities and the low standard of living seen in the Dark Ages is a warning of what can happen when ignorance and dogma trump human ingenuity and when we extinguish our faith in the betterment of humankind via the processes of innovation. This closing happens only when we allow a small group of elites to control our thoughts and actions—thus strangling innovative thoughts and creative actions. We may not all be creative but we must all be allowed to *try to be* creative for the system to work effectively and generate the most new and radical ideas through inventions.

Though a small percentage of people might disagree, most people would wholeheartedly agree that humankind in general is better off today with the innovations of the free and democratic world. The facts speak for themselves. In general, people across the world live longer, are wealthier, and in much healthier conditions than ever before in history. This phenomenon is not subject to only a small population of Western elite countries. Freer trade, freer societies, and freer thinking have all contributed to this dramatic increase in the betterment of human lives. Granted there is still corruption, still fear, still uncertainty and struggles, and we are not all *rich* by any means. However, in general no other

generation of humans who lived in the past and across the entire face of the earth has enjoyed such prosperous and peaceful times (despite the fact that wars and poverty still exist—but not to the same extent as they did). All of this has happened as the world doubled, and may perhaps triple, its population! Overall, this can be seen as triumphs for freedom and the expression of creative and innovative thought.

The preceding may seem like I am verging on diatribes of ideological expression against those that do not believe in freedom and creative thought—and of course in this day and age we have our share of such fanatics. However, the implications of the analysis are clear and not based on ideology. The fact of the matter is that innovation does not happen unless people can take risks to change the world without fear of retaliation for having even stated that the world needs changing. Even in the United States, innovative people are attacked for their ideas but the general philosophy is to accept that debate and disagreement is fine as long as free expression is not stamped out completely. We may agree to disagree but we still accept that others have their right to have thoughts independent of our own. As I have written elsewhere (Johnson 2006), if China is to become a truly innovation-based nation it will need to move further toward democratic practices and principles based on a free society—one in which merit and arguments based on facts and not position are the trump cards that win favor.

I have asked myself ever since first pondering on China and its efforts toward indigenous innovation whether there may be a new phenomenon here—a true middle way that we may not yet understand. However, the more I have explored this elusive *middle way*, the more I come to understand that it may represent a desire to return to the traditional ways of China and its former position in the world. Much like the notion of man trying to get back to the womb, the Chinese move forward by looking back, with longing and desire for the day when they were isolated and self-sufficient and needed "no idle trinkets from abroad."

In many ways, what I have witnessed is similar to this—the more things change, the more they stay the same. Today's efforts toward indigenous innovation by China are similar to the Qing Emperors' efforts to isolate the country from foreign influence. The only difference now may be the influence China now has on the rest of the world so that it is

reciprocal (which can be a good thing in the overall network of things). Analogous to the "800 lb Gorilla" cliché, it is now the billion-plus-pound dragon in the room that we cannot ignore.[3] However, neither would I fear that the dragon is *knocking at your door* and ready to burn your house down. Certainly, gone are the days when we could just see China as a cheaper alternative for manufacturing our plastic goods to be sold in the West. In fact, as I was just about to send this book to the publisher for printing, news came of Tsinghua University researchers' discovery of a shape-shifting metal, Galinstan, which if developed could have many important applications (Starr 2015). For sci-fi fans, one fantasy is that such technology could create robots like the T-1000 from the Terminator movies. While far-fetched, it is clear that Chinese Science and Technology (S&T) capabilities are strong. The tail has wagged, and the dragon is here to stay. But can its strengths in S&T be tamed and transformed to create new and exciting products and services? In essence, can the middle way lead to true innovation for a peaceful and prosperous world?

I end with a case of one future of industrial innovation in China as implied in the efforts toward its building of a commercial aircraft industry. The reader will note that I have a lot of questions in this chapter without much concrete answers. The reason for that is that absolute answers do not yet exist for these questions. But as Einstein once stated—"the important thing is to not stop asking questions." With that, I encourage the reader to continue studying China and its innovation efforts and to keep searching for more data to explore the questions I have posed here. If we approach it from the right perspectives we will all be better off, as people across the globe (and not just China) become truly more innovative and develop proactive innovation systems!

Case: Flying into the Future—Building a Commercial Aircraft Industry in China

One of the major projects earmarked in the MLP-2020 document was the creation of a sustainable home-grown commercial aircraft industry. Use of civil aviation as a means of transportation has grown rapidly in China, particularly in the last decade during the glory days of the country's economic expansion. As a proxy for this growth, Figure 8.3 shows

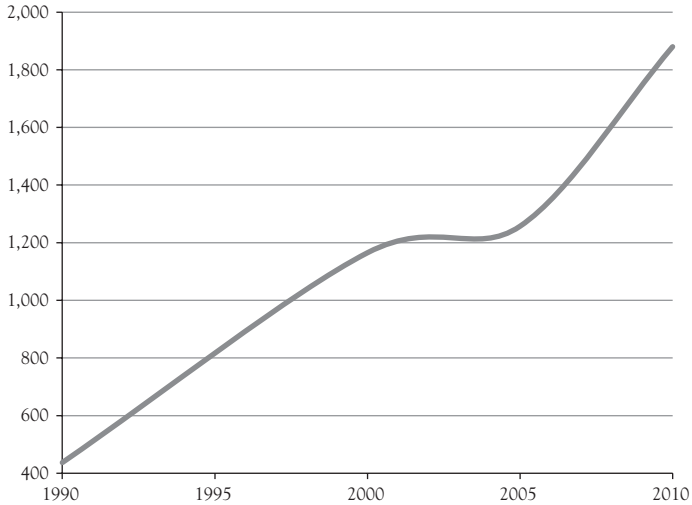


Figure 8.3 Growth in number of regular civil aviation routes (1990–2010)

Data Source: National Bureau of Statistics (2013).

a classic S shaped curve in the development of domestic commercial air routes. Growth today is even more pronounced such that a new growth curve was spawned in 2010, which had 1,880 routes. By 2012, it had increased by 31 percent with an impressive exponential growth pattern. See Figure 8.4.

The first attempt toward an indigenous commercial aircraft industry was the creation in 2008 of the Commercial Aircraft Corporation of China Ltd. (COMAC). It is a state-owned enterprise formed by the State Council's approval and a consortium of other government-affiliated companies, including Baosteel and Sinochem Corporation. The COMAC website states that their mission is "to let China-made large aircraft *fly in the blue sky!*" (emphasis added). The connection to the indigenous innovation effort of the country is made clear when the website refers to

> large passenger aircraft [as] the embodiment of the nation's industrial and technological standing as well as the comprehensive power … praised as "the flower of modern industry" and "a pearl in modern manufacturing industry." The objective is then

> specifically spelled out as: "To build the large aircraft program into a symbol for the reform and opening up policy in the new era and for creating an innovative nation, and to build COMAC into a world-class aviation enterprise" (COMAC 2015).

The two planes designed by COMAC are the ARJ21 and C919. The latter was introduced at the Singapore air show in 2014 and supposedly had 400 orders from mostly Chinese customers. Most of the critical parts like the engine are still sourced from foreign companies and there is ongoing concern that quality issues in assembly might hamper the success of the ventures (Singh 2014). After all, there is a certain amount of sensitivity to safety issues inherent in commercial flight. Modern aircraft are incredibly complex systems with little room for error in design and manufacturing. This initial hurdle of building *consumer confidence* is similar to the situation that materialized in high-speed rail, (HSR). Safety issues became paramount particularly after the Wenzhou accident that killed 40 people.

These concerns will undoubtedly slow expansion of the sales of Chinese-made aircraft in other countries. The domestic orders are

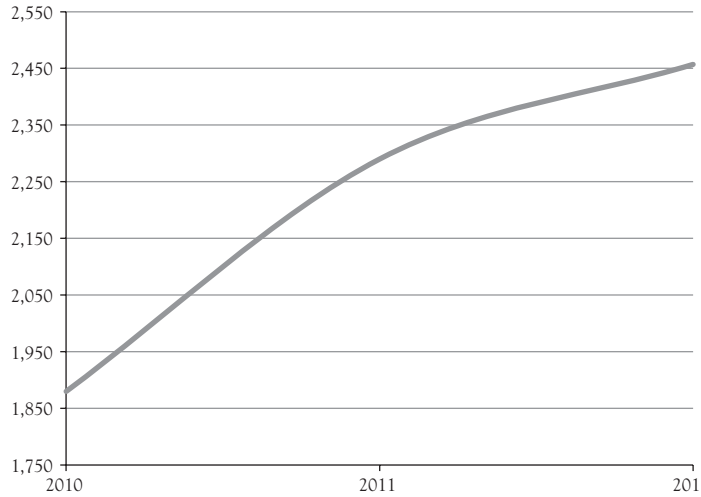


Figure 8.4 Growth in number of regular civil aviation routes (2010–2012)

Data Source: National Bureau of Statistics (2013).

indicative of the intense drive by China to source internally for its technological needs while the industry is still nascent. But like HSR these early orders, spurred by the indigenous innovation spirit, may help build the competencies needed for COMAC to become more innovative and efficient in the future. In a relatively short time COMAC may become a competitive industry foe within the world market. For example, the COO of Airbus, John Leahy, stated in 2014 that he could foresee the Chinese being a major competitor in the industry in about 20 years. He cited the time it took Airbus to go from idea to a serious international contender that could compete against the U.S.-based aircraft goliath, Boeing (Harjani 2014).

Only time will tell whether China will succeed with its efforts toward an innovation-based society that includes commercial aircraft design and manufacturing. One thing is clear, however, in our analysis of China and its innovation efforts: The dragon is here to stay; just beware of its wagging tail!

Notes

Chapter 1

1. In general, planning is not an impediment to innovation as long as government intervention remains arm's length and focuses on making the investments in infrastructure, financial motivations, and general cultural milieu that support innovation activities. Central planning becomes an impediment when it dictates actions and micromanages the process usually focusing on quantity rather than quality issues, which are a hallmark of innovation. These issues take up much of the space in this book.
2. I am reminded of a case in an old operations management textbook, perhaps apocryphal, that told of a whole squad of managers who were ceremonially executed after quality issues were uncovered at a Chinese refrigerators manufacturer. While certainly a dramatic response, it is also certain that such actions would not lead to successful innovation on quality initiatives. I do not think any total quality management (TQM) gurus like Deming, Juran, or Crosby would have suggested it as a remedy!
3. But is this true? Consider the environmental damage being done in China over the past decade of openness and reform. While it is true that Daoist and Zen Buddhist philosophies promote harmony with nature, it is important to note that China's government is officially atheist. Of course, Confucian philosophy is unofficially espoused, which emphasizes harmony in society but not necessarily in nature. Culture is discussed more in a later chapter. Also, note that most of the pollution is due to the overuse of Western inventions brought to China such as the automotive combustion engine. The tragedy of the commons is alive and well even in a socialist state!

Chapter 2

1. Note that Needham's encyclopedia of Historical Chinese Inventions was predicted to be only seven volumes. However, it is still being added to and edited after already completing 24 volumes!
2. Although women often exerted their influence on the emperor and Chinese politics as empress dowagers, the most recent example being CiXi in the late 1800s, there has been only one official empress in China—Wu Zetian—the sly and ambitious ruler of the Tang Dynasty.

3. For example, Wang (1993) discusses the theories of yin-yang and the five elements of nature from traditional Chinese *science*.
4. Also see their website at http://www.genomics.cn/

Chapter 3

1. Quote taken from "Records of Comrade Deng Xiaoping's Shenzhen Tour." See http://www.chinesecurrents.com/deng_xiaoping.html (accessed July 16, 2014).
2. See Lundvall "It should be remembered that when the concept (National Innovation System) was coined at the beginning of the 1980s it was still a standard assumption among economists and policy makers that reducing national nominal wages or devaluing the national currency was the most effective—and perhaps the only—way to enhance international competitiveness of domestic firms. Non-price competitiveness was seen as being of marginal importance. This shift is important since the concept was originally developed as a critical reaction and response to these simplistic ideas of competitiveness" (2007).
3. This was essentially a legally required middle-man who was needed if foreigner merchants wished to conduct trade with China via one of the trading ports where international trade was allowed.
4. See the English version of the Torch website; last accessed 01/03/2015—http://www.chinatorch.gov.cn/english/xhtml/index.html
5. See the web site https://data.un.org/CountryProfile.aspx?crName=CHINA
6. U.S. Census Bureau. http://www.census.gov/compendia/statab/

Chapter 4

1. For further reading, please see an excellent early OECD report on China's Innovation Policy, which depicts in some detail the evolution of organizational R&D in China OECD 2007, OECD Reviews of Innovation Policy—CHINA: Synthesis Report.

Chapter 5

1. See Gassmann, Beckenbauer, and Friesike (2012) for a succinct treatment of major IP enforcement issues in modern China. They introduce the concept of the IP protection star, which helps demonstrate the importance of utilizing and managing various dimensions (namely, legal, technological, business, market, and human-driven) in tackling IP protection.

2. See Boeing and Sandner's (2011) framework from Chapter 3.
3. In 1990, five patents were considered high value and the average yearly applications up until 2000 were five. As such, the value of two in 2000 might be low for a base year. Nevertheless, the early growth in patents was welcomed!
4. *Caveat venditor* is Latin for *seller beware* similar to the usual expression—*caveat emptor* (buyer beware). Note that *vendit* provides the root for words like *vendor* to mean seller. I thought this an appropriate term for those companies that have taken on the risks inherent in trying to sell within the Chinese market.

Chapter 6

1. 14 million seems high but divide it by 1.4 billion Chinese and it works out to about 1 percent. In the United States, 4 million teachers in a population of 322 million is about 1.3 percent.
2. There is a legitimate criticism to be made that the U.S. education has over-emphasized the creative aspects of education and forgotten the importance of the basics mentioned later in the case of this chapter. This re-enforces the idea that the model and the educational processes are cumulative. Creativity without practicality is art; practicality without creativity is mere survival. Neither, though both may be important, is what we would consider innovation based on our commercial and economic interests.

Chapter 7

1. Teece's model also pointed out the importance of both invention and commercialization as applying to the concept of innovation. Essentially, his model suggested that inventors made money when a strong appropriability regime made imitation difficult and when complementary assets were either unimportant or held by the inventor themselves. It explained why the first diet cola, RC Cola, as well as other first-to-market products and seemingly better technologies like the Dvorak typewriter keyboard (versus the QWERTY) were not successfully marketed by their inventors. For the latter example, Dvorak keyboard improved key strokes by a significant order once people learned the new technique for using the board. The *complementary assets* that conspired against the Dvorak keyboard's success, however, were fixed manufacturing standards such that manufacturers did not want to update their configurations and the fact that consumers themselves had already invested in learning how to effectively type with QWERTY

keyboards. Despite being, arguably, a *better mousetrap*, the Dvorak keyboard remains a curiosity.

Chapter 8

1. Actually, perhaps he was not as much at heart a communist as we assume. He was sent to the country-side for reforming and re-education early in his career as a communist party member because of the suspicions of Mao that he was not faithful to the cause. However, after he rose to power and with the perspective of the need for stability and harmony in Chinese society, he cracked down hard on student protesters during the Tiananmen Square protests of 1989. These actions, while brutal, may also be seen in light of his pragmatic approach to political action. In his mind, reform was good but not at the expense of anarchy—at least as he must have perceived it at the time.
2. Note that there is no actual equivalent in Mandarin for the word *innovate*. As is the case with ideographic languages, Mandarin consists of combinations of *ideas* that when combined result in some greater more complex concept. For instance, if you look up *innovate* in Mandarin you may get the expression *chuàngxīn*, which literally means *create new* or often seen as *blaze a trail*. Interestingly, a homonym of *chuàng* means sorrowful and melancholy but can also mean create and achieve. These types of complex combinations of ideas with various meanings that are embedded in Mandarin expressions are indicative of the highly contextual nature of the language.
3. I researched how much a real gorilla in the wild weighs and interestingly it is much smaller than the proverbial 800 lbs—large males actually weigh in at about 400 lbs or so. Of course, dragons do not exist but the billion pounds is of course analogous for the number of Chinese citizens.

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Innovation in China

The Tail of the Dragon

William H.A. Johnson

The word innovation is often used today regarding China, as if the concept were new to the Eastern country. Most people know, however, that China was a juggernaut in creating new technologies and at one time was the innovation king of the world—but that was at least seven centuries ago! Today, the great oriental power is attempting once again to take the throne of innovation for its own.

This desire to usurp the throne, which had been diligently taken by the West during the Scientific Revolution, has placed an almost unrealistic emphasis on innovation. In *Innovation in China: The Tail of the Dragon*, the author explores the issues and actors involved in making innovation the emphasis in China. He uses a simple systems model of innovation and various perceptual lenses. The lenses are aimed at the historical, economic, political, legal, educational and cultural elements of an innovation-based society. After reading the book the reader will understand more about how innovation is happening in China and by whom. More importantly, the reader will begin a journey of learning more about where the country is going as it relentlessly continues its drive to create an innovation-based society and to become once again, in terms appropriate to its history, the 'Emperor of Innovation'.

Dr. William H.A. Johnson is a tenured associate professor of management at the Black School of Business, Pennsylvania State University—Erie, The Behrend College. Professor Johnson received his PhD from Schulich School of Business, York University, Canada and teaches in the graduate Masters of Project Mgmt (MPM) and undergraduate programs. He was interim director of the MBA programs of the Black School of Business at Penn State Erie in 2013. His research is published in a number of innovation-based journals, and he coauthored, *Project Strategy and Strategic Portfolio Management: A Primer*, with Dr. Diane Parente; also for Business Expert Press.

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ISBN: 978-1-60649-440-0

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