

Fan, Peilei

Working Paper

Catching up in economic transition: Innovation in the People's Republic of China and India

ADB Working Paper, No. 809

Provided in Cooperation with:

Asian Development Bank Institute (ADBI), Tokyo

Suggested Citation: Fan, Peilei (2018) : Catching up in economic transition: Innovation in the People's Republic of China and India, ADB Working Paper, No. 809, Asian Development Bank Institute (ADBI), Tokyo

This Version is available at:

<https://hdl.handle.net/10419/190230>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.



<https://creativecommons.org/licenses/by-nc-nd/3.0/igo/>



ADB Working Paper Series

**CATCHING UP IN ECONOMIC
TRANSITION: INNOVATION IN THE
PEOPLE'S REPUBLIC OF CHINA AND INDIA**

Peilei Fan

No. 809
February 2018

Asian Development Bank Institute

Peilei Fan is an associate professor of urban and regional planning at Michigan State University.

The views expressed in this paper are the views of the author and do not necessarily reflect the views or policies of ADBI, ADB, its Board of Directors, or the governments they represent. ADBI does not guarantee the accuracy of the data included in this paper and accepts no responsibility for any consequences of their use. Terminology used may not necessarily be consistent with ADB official terms.

Working papers are subject to formal revision and correction before they are finalized and considered published.

The Working Paper series is a continuation of the formerly named Discussion Paper series; the numbering of the papers continued without interruption or change. ADBI's working papers reflect initial ideas on a topic and are posted online for discussion. Some working papers may develop into other forms of publication.

The Asian Development Bank recognizes "China" as the People's Republic of China.

In this report, "\$" refers to US dollars.

Suggested citation:

Fan, P. 2018. Catching Up in Economic Transition: Innovation in the People's Republic of China and India. ADBI Working Paper 809. Tokyo: Asian Development Bank Institute. Available: <https://www.adb.org/publications/catching-economic-transition-innovation-prc-and-india>

Please contact the authors for information about this paper.

Email: fanpeile@msu.edu

I would like to acknowledge the financial support of the Asian Development Bank Institute (ADBI) to attend the ADBi-NSFC Conference on "Escaping the Middle Income Trap: Urbanization, Structural Change, and Sustainable Development in Asia" in November 2015 in Tokyo. I thank the meeting organizers, Guanghua Wan and Peter Morgan, for this opportunity. I appreciate the constructive comments provided to an earlier version of this manuscript from the meeting participants, particularly Kaoru Nabeshima from Waseda University, but also Yanrui Wu from the University of Western Australia and Chun-Yu Ho from Shanghai Jiaotong University. I also thank Zutao Ouyang from Michigan State University for his assistance in making Figure 5. Any opinions, findings, and conclusions or recommendations expressed in this paper are those of the authors and do not necessarily reflect the views of ADBI.

Asian Development Bank Institute
Kasumigaseki Building, 8th Floor
3-2-5 Kasumigaseki, Chiyoda-ku
Tokyo 100-6008, Japan

Tel: +81-3-3593-5500

Fax: +81-3-3593-5571

URL: www.adbi.org

E-mail: info@adbi.org

© 2018 Asian Development Bank Institute

Abstract

In this paper, I examined how the People's Republic of China (PRC) and India, two largest transitional economies in Asia, have engaged in improving their innovation capability in the economic transition. First, I measured and compared innovation capability of both countries by using not only various input and output indicators of innovation systems but also the contribution of technological progress to economic development at different periods of their economic transition. Then I compared how both countries developed their innovation capabilities by focusing on their transformation of the national innovation systems since the economic reform and evolving technology policies. Furthermore, I provided a brief view on how the emerging innovative cities in both countries became dominated the innovation activities of their respective countries.

Keywords: innovation, R&D, the People's Republic of China, India

JEL Classification: O31, O3, L65

Contents

1.	INTRODUCTION	1
2.	MEASURING INNOVATION	2
2.1	Input Indicators of Innovation Systems.....	2
2.2	Output Indicators of Innovation Systems.....	4
2.3	Contribution of Innovation to Economic Development	6
3.	NATIONAL SYSTEM OF INNOVATION AND TECHNOLOGY POLICIES	8
3.1	People's Republic of China	8
3.2	India.....	9
4.	INNOVATIVE CITIES IN THE PRC AND INDIA.....	10
5.	WHO INNOVATES?	12
6.	CONCLUSION	13
	REFERENCES	15

1. INTRODUCTION

After two to three decades of economic reform, recently both the People's Republic of China (PRC) and India have declared their ambitions to become the innovative nations in the 21st century. The PRC announced that it would transition into an "innovation-driven economy" in 2012 by its then president Hu Jintao in the 18th National Congress Party. In 2010, the President of India, Pratibha Patil, announced that the decade from 2011 to 2020 will be India's "Decade of Innovation."

Both the PRC and India made remarkable economic growth since their economic reform. The PRC lifted more of its people from poverty than India through an almost 20 times increase of its GDP per capita (GDPpc) within 36 years, from \$195 in 1978 to \$3,865 in 2014, whereas India quadrupled its GDPpc during the same period from \$301 in 1978 to \$1,235 in 2014. Though positioned as the second largest economy in the world, the PRC clearly knew that the growth model it has utilized in the past relied heavily on foreign investment, exports, and low costs of labor. This model cannot sustain the country into the foreseeable future and has already borne a dear cost, from environmental degradation to loss of jobs to competition from other lower-labor-cost countries, to the slow-down of its current economic growth. India's motivation, however, differs. Although India experienced sizable economic growth after the economic reform, its effort has mainly only benefited the urban class, with the rest of its rural population (68% of total population) still facing serious challenges to meeting the basic needs for life, from food, water, energy, to primary education and health care. The main intention of the Indian government is to promote innovation for entrepreneurship development and sustainable and inclusive growth.

An innovation driven economy for the PRC and the "Decade of Innovation" for India are not propaganda set by the national governments, but have already become the national mentality for even the normal people. Buzz words related to innovation, such as "*Chuangxin Zhongguo* (Innovative the PRC)," "*Quanmin Chuangxin* (everyone innovates)," "*frugal innovation*," "*Juggard innovation*," and "*inclusive innovation*" prevailed in different corners of the two oldest civilizations of the world (Shyama 2014; Radjou et al. 2012). It seems that both countries are well prepared to enter into the next stage of the development by innovation as a way to escape the middle-income trap, indicated by either the recent slowdown of economic growth in the PRC or the limited trickle-down to the bottom class in India.

The PRC and India share many similarities, such as a large population base with extensive territory and a long history of civilization. But they also differ tremendously; while the PRC has been mostly dominated by one language, one Han ethnicity, and its associated culture and religions, India is incredibly diverse in languages, ethnicities, cultures, and religions. Further, India has enjoyed a more democratic and liberal society. Both countries, however, have been showing great potential to re-emerge not only as world's major economic powers, but also chief innovative nations due to their technological prowess built upon their large stocks of human capital, developed public science and technology infrastructure such as research institutes and universities. They are ideal laboratories to experiment new ways of catching up through innovation, especially when cities become more significant players in national innovation activities. With a joint population of 2.6 billion and accounting for 36% of the world population in 2014, if innovation indeed has contributed to the catching-up or played an important role to these two giant's economic development, the implication is immense, not only for people of these two countries, but also the rest of the world.

To have an objective evaluation of the role of innovation played and how the PRC and India have developed their innovation capabilities, we need to answer a suite of related questions, including (1) what are the innovation capabilities of both countries and their relative positions in the world?; (2) How have their innovation capabilities evolved overtime and what are the major factors contributing to the improvement of their innovation capabilities?; (3) Can main theories on innovation and latecomers' catching up applicable to the context of the PRC and India? What are some of the unique contributions from the PRC and India to the theoretical advancement of innovation and the catching-up literature?; (4) What are the policy implications for other emerging economies or the developing countries at-large?; and (5) What are the implications of the PRC and India becoming the innovative nations for the industrialized nations, such as the US, Japan, and the Western European countries, and the newly industrialized economies, including the Republic of Korea; Taipei,China; Singapore; and Hong Kong, China?

In this paper, I attempted to address only some of the above-mentioned questions, focusing on the measurement of innovation capability, the institutional factors affecting innovation, and the rising innovative cities in the two countries. First, I measured and compared innovation capability of both countries by not only using various input and output indicators of innovation systems, but also analyzing the contribution of innovation to economic development at different periods of their economic reforms. Then I compared how both countries developed their innovation capabilities by focusing on the transformation of the national innovation systems since the economic reform and technology policies. I also provided a brief view on how the emerging innovative cities in both countries have become the focal points of the nations' innovation activities.

2. MEASURING INNOVATION

In order to reveal the evolution of innovation capability of the PRC and India, I used both the input and output indicators of the national system of innovation. These are common indicators incorporated by scholars and agencies to evaluate the innovation potential and performance (e.g., the Global Innovation Index). I thus first presented the measurements by the input indicators, i.e., the amount of R&D investment and the number of researchers in R&D. I then demonstrated the output measures such as patents, high-tech/service exports, and academic journal paper publications. In the end, I illustrated a decomposition analysis that indicates the contributions of the innovation to economic development for both countries since the 1980s.

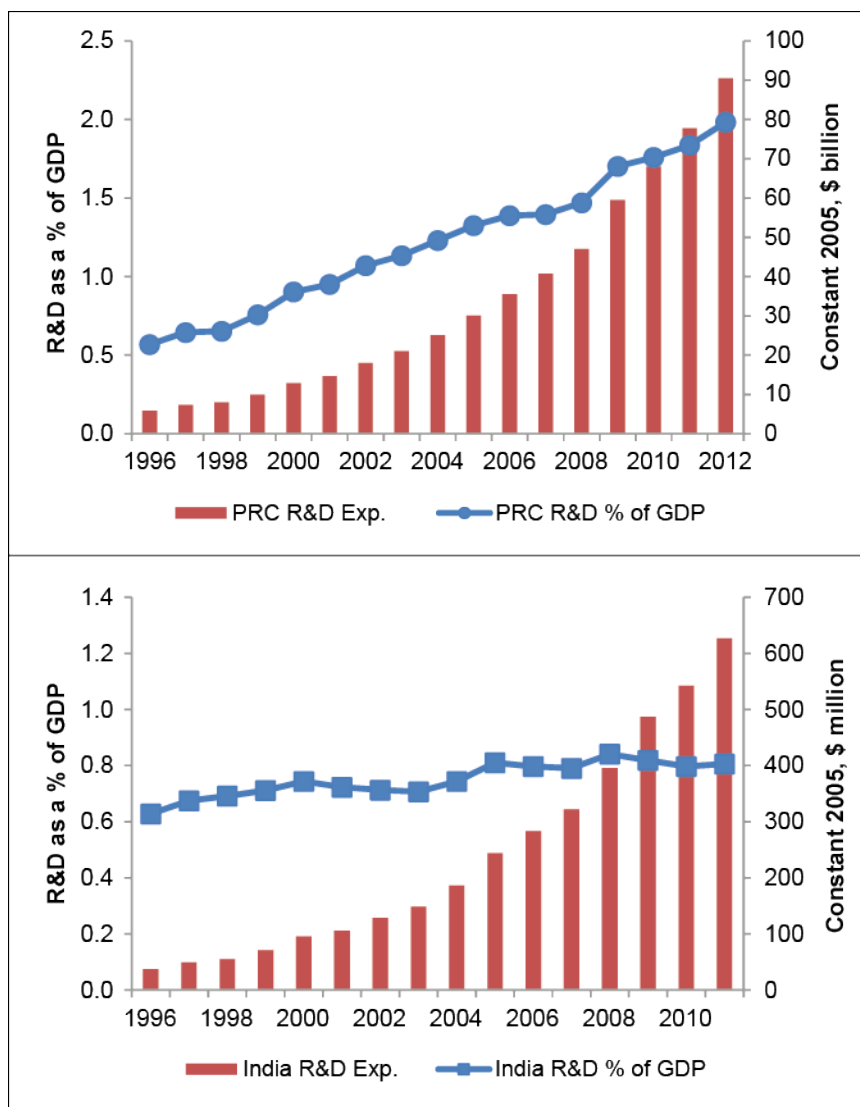
2.1 Input Indicators of Innovation Systems

2.1.1 R&D Expenditure

R&D expenditure is the most common indicator to measure the effort of innovation activities and has been considered as one of the most significant factors affecting innovation performance both at the country and the firm levels, e.g., see Griffith et al. (2004) for a result on panel data of OECD countries and other studies (Griliches and Mairesse 1984; Griliches 1984, 1986, 1998; Romer 1986, 1990; Lucas 1988). The PRC had invested heavily in R&D since the middle of the 1990s and quickly ramped up its R&D as a percentage of GDP from less than 0.6% in 1996 to 2.0% in 2012, similar to other OECD countries, who generally spent 2%–3% of GDP in R&D (Figure 1). Although India also rapidly increased its R&D investment, its R&D as a percentage to GDP remained oscillating in the range of 0.6%–0.8%, making it a sharp contrast

with that of the PRC (Figure 1). Moreover, the fact that the PRC R&D investment (\$77 billion) was more than 120 times of India (\$0.6 billion) in 2011 indicating that India has a long way to go in order to align itself with other industrialized nations seriously investing in R&D.

Figure 1: R&D Expenditure and Its Percentage of GDP, 1991–2012, the PRC (top) and India (bottom)



GDP = gross domestic product, PRC = People's Republic of China, R&D = research and development.

Source: Figure created by the author based on data from World Development Indicators (World Bank 2015).

2.1.2 R&D Personnel

Similar to R&D expenditure, the number of researchers has also been used as an important indicator for innovation potential of a nation. A comparison of the PRC and India with two other leading nations of R&D indicates that the PRC progressed very well and already surpassed the US in total researchers in R&D in 2005, whereas India has not significantly improved its human stock comparing with the PRC (Table 1). When compared in terms of researchers in R&D per million people, however, a large gap appeared as Japan and the US have much higher ratio of researchers per million

population—the PRC's figure was only 1/5 or 1/4 that of Japan and the US, whereas India was less than 1/5 of the PRC's.

Table 1: Researchers in R&D in the PRC, India, Japan, and the United States

Country	Researchers in R&D (per million people)				Total Researchers in R&D			
	1996	2000	2005	2010	1996	2000	2005	2010
PRC	439	542	859	890	476,564	685,408	1,106,429	1,191,147
India	153	111	137	159	118,538	117,184	157,187	196,875
Japan	4,947	5,151	5,360	5,151	658,751	653,384	684,888	659,726
US	3,102	3,455	3,692	3,837	928,883	974,807	1,091,279	1,187,150

PRC = People's Republic of China, R&D = research and development, US = United States.

Source: Compiled and calculated by the author based on the data from World Development Indicators (World Bank 2015).

2.2 Output Indicators of Innovation Systems

2.2.1 Patents

In this paper, I used several indicators as output measures of innovation system. First is the number of granted patents by the United States Patent and Trademark Office (USPTO). Not only has patent data been widely used as the most appropriate output measure for innovation capability, USPTO also has been regarded as one of the most credible agencies for issuing quality patents (Mansfield 1986; Barberg 1987; Griliches 1990; Hagedoorn and Cloudt 2003).¹ The brisk progress of the PRC and India in granted patents is hard to miss, especially during the last five years. In fact, most patents of both countries are from the last five years. However, they are still far behind other strong contestants in the region, such as Japan, the Republic of Korea, and Taipei, China. It is also interesting to note that comparing to the impressive growth of R&D expenditure and personnel, the PRC's output measure felt shy. For instance, while the PRC had 1.19 million researchers in R&D, more than 80% than that of Japan (0.66 million) (Table 1); however, the PRC produced only 14% of USPTO patents (45880) of what Japan had from 2010 to 2015 (318142) (Table 2).

Table 2: US Patents Granted to Selected Asian Inventors, 1970–2015

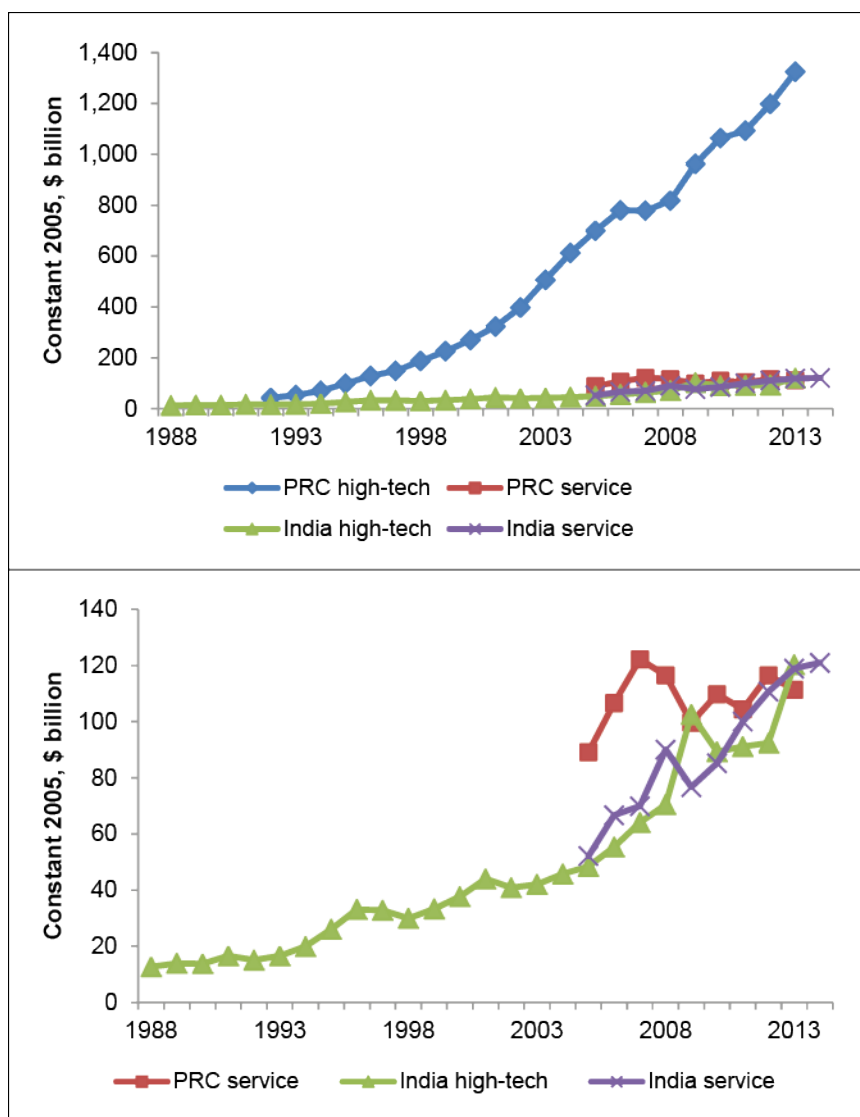
	Total	1970–1979	1980–1989	1990–1999	2000–2009	2010–2015
Japan	107,3204	9,285	128,839	251,449	365,489	318,142
Taipei, China	169,409	57	2,613	22,507	72,365	71,867
Republic of Korea	169,935	10	646	15,306	58,024	95,949
PRC	60,179	2	178	900	13,219	45,880
India	24,567	81	166	679	5,529	18,112
Hong Kong, China	13,152	123	886	2,688	5,855	3,600
Singapore	12,823	11	102	957	5,166	6,587

PRC = People's Republic of China, US = United States.

Source: Compiled by the author based on the USPTO Patent Collection Database. <http://patft.uspto.gov/> (accessed 02/08/2016).

¹ I did not use domestic patent data published by the statistical bureau of the PRC and India as the USPTO patent data can be used to compare the performance between different countries.

Figure 2: High-Tech Exports and Service Exports of the PRC and India 1992–2014



PRC = People's Republic of China, US = United States.

Note: The bottom figure is a closer look at exports of service of the PRC, high-tech and service of India. Due to the high values of the PRC high-tech export since the late 1990s, the top figure cannot reveal the detailed dynamics of these three variables.

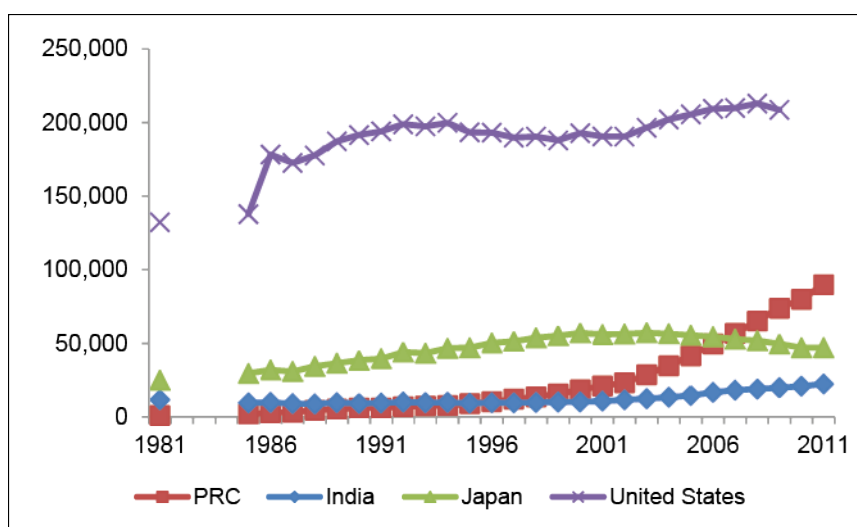
Source: Figure created by the author based on the data calculated from the World Development Indicators (World Bank 2015).

Both high-tech and service export can be considered as one output measure of innovation systems, especially for measuring the economic benefits of innovation activities (Fan 2011a and 2014), despite the debate that high-tech exports may not reflect improvements in innovation capacity (Feenstra and Wei 2010; Amiti and Freund 2010; Wang and Wei 2010; Berger and Martin 2013). The PRC has steadily improved its high-tech export, whereas its service export has not fared so well, comparing to the staggering performance of high-tech export (Figure 2). For India, both high-tech and service exports have steadily increased, although at a much slower pace when compared with the PRC's high-tech export.

2.2.2 Scientific and Technical Journal Articles

To complement the patent and high-tech export, here I also used scientific and technical journal articles as an indicator for the more basic dimension of innovation (Figure 3). According to the World Bank, this indicator reflects journal articles published in the several main science and technology fields, in journals classified by the Institute for Scientific Information's Science Citation Index (SCI) and the Social Sciences Citation Index (SSCI) (World Bank 2015). As the figure illustrated, the PRC started its momentum of publishing journal articles since the late 1990s and surpassed Japan in 2007. However, it still lagged far behind the US, the leader in scientific publication. In comparison—although with a number of 11,725, India had more than 10 times the amount of journal articles than the PRC (1,100) in 1981—it moved slower and gradually improved its number. In 2011, its number of journal articles was about a quarter of what the PRC had.

Figure 3: Scientific and Technical Journal Articles Published by the PRC, India, Japan, and the US, 1981–2011



PRC = People's Republic of China, US = United States.

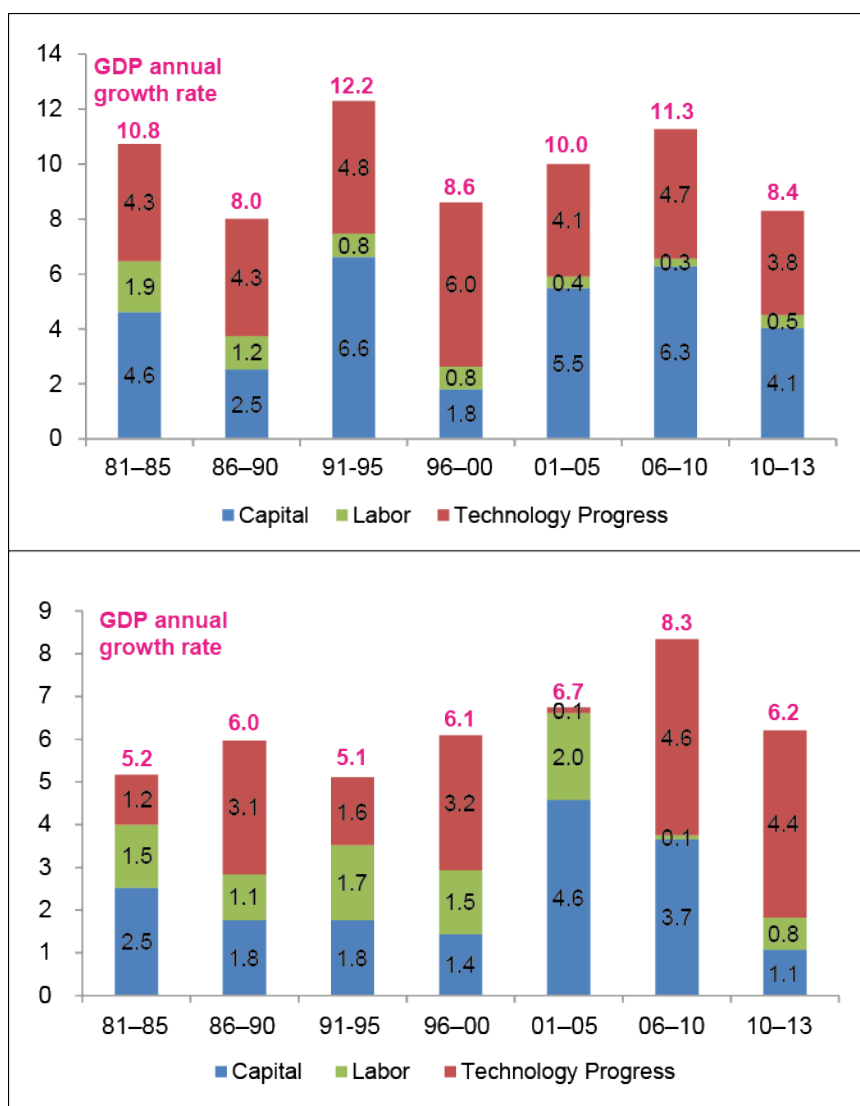
Note: the author created a similar figure based on World Development Indicators (World Bank 2013) in another article (Fan 2014). This figure here has new data from 2009–2011 and added India's data, based on World Development Indicators of 2015.

Source: Figure created by the author based on data from World Development Indicators (World Bank 2015) and updated from Figure 4 of (Fan 2014).

2.3 Contribution of Innovation to Economic Development

As GDP growth can be decomposed into the contributions of capital, labor, and technology, the share of technology progress or innovation to economic development can also be measured (Fan and Watanabe 2006). Here based on previous works, i.e., Fan and Watanabe (2006) on the PRC (from 1981–2000) and Fan (2011a) on the PRC and India (from 1981–2004), I updated the analysis with the newly available data from 2005 to 2013. For a detail method description, please see Fan and Watanabe (2006). The results (Figure 4) indicate that innovation, here labeled as technological progress, continued to be an equally important major driving force vis-à-vis capital for economic development in the PRC. For India, after a period of stagnation, innovation bounced back and became the most important driving force for its economic growth from 2006 to 2013.

Figure 4: Contribution of Technological Progress to Economic Growth in the PRC (Top) and India (bottom), 1981–2013 (%)



PRC = People’s Republic of China.

Note: The calculation in this paper on the PRC and India is a little bit different from Fan and Watanabe (2006) (for the PRC 1981–2000) and Fan (2011b) (for the PRC and India 1981–2004). Here I used all the data from the WDI of (World Bank 2015), except the labor data of 80–89 for which I used WDI 2006, while Fan and Watanabe (2006) used WDI (World Bank 2003) and the PRC Statistical Yearbook (National Statistical Bureau 2005) and Fan (2011b) used WDI (World Bank 2006). However, the general trend that resulted from this calculation is similar to Fan and Watanabe (2006) for the PRC till 2000 and Fan (2011a) for the PRC and India till 2004.

Source: the author calculated based on the following data sources: GDP, labor, and growth capital formation rate: World Development Indicators (World Bank 2015), except for labor data of 80–89, which is from WDI of 2006 of (World Bank 2006).

3. NATIONAL SYSTEM OF INNOVATION AND TECHNOLOGY POLICIES

The national system of innovation (NSI) (Freeman 1987, 1995; Lundvall 1992; Nelson 1993) has remained to be the most popular approach to analyze innovation in a country. It is no surprise that there are also a number of studies that use the NSI for innovation in the PRC (see, e.g., Xue 1997; Gu 1999; Liu and White 2001; Fan and Watanabe 2006; Motohashi and Yun 2007; Altenburg et al. 2008; Fan 2011a and 2014) and India (Lal 1995; Katrak 1998; Kumar and Jain 2003; Fan 2011a; Abhyankar 2014). In this section, I will highlight the major changes of NSI and the major technology policies that have been advocated by the governments since the economic reform of both countries.

3.1 People's Republic of China

Before the economic reform in 1978, the PRC's NIS is similar to other countries of central planning systems. The most distinguished feature is a complete separation of science and technology (S&T) activities in public research institutes from manufacturing activities of state-owned enterprises (Xue 1997). The reform in the 1980s and 1990s thus intended to integrate two sectors by encouraging the research institutes to conduct more R&D with industrial potential and the enterprises to do more industrial R&D (Liu and White 2001). Please refer to Gu (1999) and Liu and White (2001) for a detailed analysis of the reform of NIS up to 2000, and Fan (2014) for updates after 2000.

Along with the reform of the NSI, the Government of the PRC has also used national technology policies to boost both basic research and innovation for industries (Table 3). Policies enhancing the basic research in the PRC can be exemplified by the well-known High-Tech Research and Development Program (Program 863) in 1986 and the National Program for Priority Basic Research and Development (Program 973) in 1997, which provided large amounts of financial resources to research institutes, universities, and companies tackle the key scientific challenges in identified national priority areas, such as agriculture, health, information technology, energy, environment. Policies focusing on innovation for industries include the Torch Program initiated in 1988 which set up high-tech parks for developing high-tech industries and the establishment of the PRC Association for Small & Medium Commercial Enterprises in 2008 to enhance innovation capacity and market competitiveness of domestic firms. The long-term technology policies include the Medium- and Long-Term National Plan (MLTP) issued in 2006, aiming to promote a S&T development strategy and enhance innovation capacity for the nation. Selective development is to occur in energy, water resources, environmental protection, innovation in information technology, new materials, advanced manufacturing technology, and biotechnology. This corresponded to the PRC's plan to move towards an innovation-driven economy as mentioned in the introduction. Realizing the importance of innovation for regional development, the PRC also initiated programs using innovation as an important tool, e.g., the 11th Five-Year Plan on Western Region Development (2006) and Framework for Development and Reform Planning for the Pearl River Delta Region (2008-2020) (2008).

Table 3: Major Technology Policy Initiatives in the PRC Since the Economic Reform

Year	Policy Initiative
1978	First National Science Congress, held on March 18
1982	Key Technologies Research and Development Program
1985	Decision on the Reform of the Science and Technology System, issued after the National Working Conference of Science and Technology
1986	High-Tech Research and Development Program (Program 863)
1988	Torch Program
1990	First group of 27 high-tech parks set up
1991	The first high-tech park (Zhongguancun High-Tech Park) established
1993	Technology Progress Law enacted
1995	Decision on Accelerating S&T Development announced by the State Council
1995	211 Program to construct 100 top universities in the 21st century
1996	Technology Transfer Law enacted
1997	National Program for Priority Basic Research and Development (Program 973)
1998	Knowledge Innovation Program (1998–2010)
1999	Decision on Enhancing Technology Innovation, High-Tech Development and Industrialization issued
2006	Medium- and Long-Term National Plan (MLTP) for Science and Technology (S&T) Development 2006–2020
2006	The 11th Five-Year Plan on Western Region Development
2006	National S&T Development Plan for the 11th Five-Year Period (2006–2010)
2008	Establishment of the PRC Association for Small & Medium Commercial Enterprises
2008	The Thousand Talents Program
2008	Framework for Development and Reform Planning for the Pearl River Delta Region (2008–2020)

PRC = People's Republic of China.

Source: Adapted from Fan and Wan (2006, Table 1) and Corey et al. (2014, Table 1).

3.2 India

Many elements of India's NSI, such as public research institutes and universities, can be traced back to its colonial period, where, the country's legal, financial, education, and governance systems were set up for Modern India (Abhyankar 2014). India's independence in 1947 signified that the country closed its economy with heavy central planning as its main characteristic (Lal 1995; Abhyankar 2014). Similar to the PRC's NSI, India's NSI has also been heavily criticized for its separation of S&T from industrialization. Nevertheless, it is also this period that the country laid the ground for science and technology. Key entities in India's NIS directly participating innovation include various councils and research units under different ministries, about 3,000 publicly funded research institutes by 1998 (Kumar and Jain 2003), 280 public universities and more than 150 private universities, and 2,500 R&D centers of companies as of 2014 (Abhyankar 2014). In addition, supporting structures and other main stakeholders include financial institutions (banks and venture and angel capital), companies, and individual innovators.

Even before it staged the economic liberalization in 1991, India already started reforming its national innovation systems, particularly its poorly performed industrial research institutes (IRIs) (Katrak 1998). The government gradually reduced its funding to these IRIs and required them to earn revenues from activities such as commercialization of their research results to cover at least 30% to their expenditures since the 1990s (Katrak 1998; Sikka 1998). Similar to the PRC, the government also utilized technology policies to encourage innovation since the 1980s (Table 4). Major policies particularly highlighted financing innovation and indigenous technology development, such as Technology Policy Statement (1983), Research and Development Cess Act (1986), and Technology Development Board Act (1995). It also underlined technology development for industrialization, with schemes of Technological Self-Reliance, the Sponsored Research and Developments Scheme, and the Program for Acceleration of Commercial Energy Research (Kumar and Jain 2003). Chief milestones in the new millennium include the New S&T policy (2003); the setup of the National Innovation Council in 2010; the IT policy (2012); the Science, Technology and Innovation Policy (2013); and India Inclusive Innovation Fund (2014). Set up as a think tank for innovation strategies in India, National Innovation Council was to develop a national roadmap for innovation for 2010–2020. It is interesting that the country issued an IT policy in 2012, aiming at “maximally leverage the power of ICT to help address monumental economic and developmental challenges the country faces” (Government of India 2012: 3). It is worth mentioning that India Inclusive Innovation Fund’s aim is to encourage innovation for inclusive development, i.e., to solve the problems of the poorest section of the society, focusing on health care, food and nutrition, agriculture, education, energy, financial inclusion, environment technology, etc.

Table 4: Major Technology Policy Initiatives in India

Year	Policy Initiative
1958	Scientific Policy Resolution
1970	Indian Patent Act
1983	Technology Policy Statement (new draft announced in 1993, but not adopted)
1986	Research and Development Cess Act
1988	Announcement of the Venture Capital Guidelines
1995	Technology Development Board Act
1996	Announcement of CSIR 2001: Vision and Strategy; A Securities and Exchange Board of India (Venture Capital Funds) Regulations 1996 (replacing the 1988 Venture Capital Guidelines)
1999	Amendment of the Indian Patents Act 1970
2000	Announcement of New Millennium Indian Technology Leadership
2003	New S&T Policy
2010	Establishment National Innovation Council
2012	The IT Policy
2013	The Science, Technology and Innovation Policy
2014	India Inclusive Innovation Fund

Source: Adapted from Mani (2004) for policies from 1958 to 2003, added by the author for policies after 2003.

4. INNOVATIVE CITIES IN THE PRC AND INDIA

As we entered into an era of urban world with more population living in cities, the PRC and India also urbanized rapidly. The PRC leaped its urbanization ratio from 18% in 1978 to over 54% in 2014 whereas India progressed from 26% in 1991 (22% in 1978) to 32% in 2014. Some scholars have argued that we are living in a world where we

should change our mental images to organize the world by cities rather than by the traditional sovereign national boundaries, because cities have become increasingly important growth engines for regional and national economy and have always been the focal points for political, cultural, and especially for innovative activities (Petrella 1995; Florida 2000; Scott 2000; Audretsch and Feldman 2004). For instance, when examining the global innovation activities of the telecommunication industry, it is the cities such as Silicon Valley, San Diego, Stockholm, Dallas, Bangalore, and Shenzhen that distinguished themselves, much more so than their respective countries, as illustrated by R&D globalization strategies of the leading companies in the industries (Fan 2011b). It is therefore important to downscale our current innovation study of the PRC and India to the levels of cities.

To measure the innovation performance or potential of cities, scholars and agencies have coined up innovation indexes at the city level, in addition to innovation index measured at the country level, such as the Global Innovation Index and the Bloomberg Innovation Index.² Examples include the Creative Class Index by Florida (2002) mainly focusing on cities in the US and Canada, and the Innovative City Index by 2thinknow, claimed as the world's first innovation agency, classifying and ranking 445 cities worldwide by their potential for innovation economy since 2007 (2thinknow 2015). For the PRC and India, the Innovative City Index revealed that Shanghai was one of the nine 1st tier innovative cities in Asia, dubbed as a "nexus," while 4 cities, Beijing, Shenzhen, Mumbai, and Nanjing, were the second tier cities called "hubs", and 11 Chinese cities and 4 India cities, i.e., Suzhou, Bangalore, Chengdu, Guangzhou, Hangzhou, Changchun, Tianjin, Dalian, Delhi, Chennai, Pune, Dongguan, Xi'an, Xiamen, and Wuhan were evaluated as the third tier innovative cities, or "nodes" in its 2014 ranking. The composite index of 2thinknow may be an extreme example of comprehensiveness, as it examines 162 indicators covering 31 community and industrial segments of three factors: cultural assets, human infrastructure, and network markets.

Here, I use a simple indicator based on only USPTO patents to reveal how major several innovative cities can dominate the innovation stage of the PRC and India (Table 5). While the top three cities in the PRC together generated over 61% of the PRC's USPTO patent, the top city in India, Bangalore, by itself, created over 36% that of India. In the PRC, Shenzhen, Beijing, and Shanghai, are listed as the three most innovative city regions, followed quite distantly by four others in decreasing order, Nanjing, Guangzhou, Suzhou, and Tianjin—all located closely to these three cities. It is interesting to note that it is Shenzhen, rather than Beijing, who led in patent number as Shenzhen was granted 15,942 patents, while Beijing was issued 11,242 patents. Geographically, as all the top seven cities are located in eastern the PRC, this uneven spatial pattern implies the regional development challenge for the central and the western PRC in the knowledge economy.

² The Global Innovation Index created by World Intellectual Property Office (WIPO), Cornell University, and Institut Européen d'Administration des Affaires (European Institute for Business Administration, or as INSEAD) ranked innovation performance 143 countries by measuring various aspects of the enabling environment for innovation and the innovation outputs, using 81 indicators. The Bloomberg Innovation index similarly ranks countries and economies in innovation, but using a much simpler formula, looking at only 6 indicators in R&D, manufacturing, high-tech companies, post-secondary education, research personnel, and patents.

India’s city innovation landscape presents a much more balanced geographic feel since its top innovative cities spread out the subcontinent evenly. Bangalore is unarguably the leader for all Indian cities—with its patent number of 8,557, just 118 less than the sum of the other six top cities (8,657). Moreover, Delhi, Pune, Hyderabad, and Mumbai are close competitors as they have similar numbers of patents ranging from 1400s to 2100s, while Chennai and Kolkata trailed not too remotely with patents of 934 and 636. For both countries, the leading innovative cities, Shenzhen and Bangalore, are neither the largest cities, measured by population or GDP, nor the most R&D resourceful cities by official standard, by the number of public research institutes, universities, or R&D personnel. They are emerging cities most actively in industrial R&D in their respective countries. While it is beyond the scope of this paper to examine more details of the innovative cities in the PRC and India, this is certainly an exciting area deserving more future research. As both the PRC and India aim to move towards an innovation-based economy, the inequality of innovation capability has profound impact on inequality of regional economic development.

Table 5: US Patents Granted to Selected Cities in the PRC and India, 1970–2015

City	Patents	City	Patents
Shenzhen	16,267	Bangalore	8,787
Beijing	11,598	Delhi	2,152
Shanghai	9,072	Pune	1,859
Nanjing	895	Hyderabad	1,755
Guangzhou	758	Mumbai	1,492
Suzhou	742	Chennai	961
Tianjin	603	Kolkata	552
PRC	60,179	India	24,567

PRC = People’s Republic of China, US = United States.

Note: For Mumbai, both Mumbai and Bombay were searched. For Kolkata, both Kolkata and Calcutta were searched.

Source: Compiled by the author based on the search at USPTO Patent Collection Database <http://patft.uspto.gov/>

5. WHO INNOVATES?

Under the strong industrial policies and protection of the domestic market, Japan and the Republic of Korea, the two earlier industrializing economies in Asia have not depended on foreign direct investment and their domestic companies have grown into global players (Johnson 1982; Amsden 1989). In the contemporary context of an increasingly globalized economy what role has MNC played in innovation in the PRC and India? Multinational corporations (MNCs) have gradually globalized their R&D activities, first to the OECD countries, but recently also to emerging countries such as the PRC and India (Santos-Paulino et al. 2014). An examination of top US patent receivers in the PRC and India reveals that while the PRC’s innovation has depended on both domestic organizations and MNCs, India relied mostly on MNCs (Table 6). From 2010 to 2014, domestic organizations, such as Huawei, ZTE, Tsinghua University, and Shenzhen China Star, are listed as top 10 receivers of USPTO patents. Among the leading innovators of MNCs, Hon Hai/Foxconn Technology Group—to which Hong Fu Jin Precision Industry, Hon Hai Precision Ind., and Shenzhen Futaihong Precision Industry all belong—Microsoft and IBM are distinguished players. Looking at the top 10 list of India, eight are US-based MNCs in the information technology industries, including IBM, GE, TI, Honeywell, HP, Semantic,

Oracle, Microsoft, implying a relative weak capability of domestic organizations in innovation capability.

Table 6: Top 10 USPTO Patent Receivers in the PRC and India, 2010–2014

PRC	2010	2011	2012	2013	2014	Total
Huawei Technologies Co., Ltd.	245	352	503	621	690	2,411
Hong Fu Jin Precision Industry (Shenzhen) Co., Ltd	308	374	599	700	351	2,332
Individually Owned Patent	206	193	295	281	325	1,300
ZTE Corporation	22	33	99	269	701	1,124
Tsinghua University	101	100	147	189	230	767
Microsoft Corporation	160	133	169	143	125	730
Hon Hai Precision Ind. Co., Ltd	207	168	99	70	62	606
Shenzhen Futaihong Precision Industry Co., Ltd	69	107	203	149	77	605
Shenzhen PRC Star Optoelectronics Technology Co., Ltd.	0	0	3	102	431	536
International Business Machines Corporations	26	64	106	158	139	493
India	2010	2011	2012	2013	2014	Total
International Business Machines Corporation	86	114	135	239	318	892
General Electric Company	53	86	115	131	124	509
Texas Instruments, Incorporated	55	40	67	64	83	309
Council of Scientific and Industrial Research	67	28	39	54	78	266
Individually Owned Patent	41	31	52	68	74	266
Honeywell International Inc.	35	45	37	66	73	256
Hewlett-Packard Development Company, L.P.	26	44	56	42	69	237
Symantec Corporation	5	13	33	82	89	222
Oracle International Corporation	13	27	34	49	61	184
Microsoft Corporation	22	33	36	40	48	179

Source: USPTO. Patenting By Geographic Region (State and Country), Breakout By Organization, Count of 2010–2014 Utility Patent Grants, By Calendar Year of Grant. Available at http://www.uspto.gov/web/offices/ac/ido/oeip/taf/stcsg/regions_stcorg.htm

6. CONCLUSION

In this paper, I examined innovation in the PRC and India during the economic transition by first measuring the innovation capabilities then evaluating the contribution of innovation to economic development through a decomposition analysis. In terms of input indicators of innovation, such as R&D expenditure and R&D personnel, both countries made good progress, although the PRC has leaped forward with a much greater stride. Similar trends can be found in the output indicators such as patents, high-tech/service export, and scientific and technical journal paper publications. The analysis on the contribution of innovation to economic development has shown that innovation continued to be an equally important driving force as capital for economic development for the PRC, whereas innovation became the most important driving force for India from 2006 to 2013, after a short period of setback from 2001 to 2005.

The review on the transformation of the national system of innovation indicates that the transformation of both countries focused on breaking the complete separation of innovation activities from manufacturing activities. Both countries have issued a set of national technology policies and have all included high-tech industrialization and the development of indigenous technologies. While the PRC's policies have also set up resources for basic research through its Program 863 and Program 973, as well as for regional development, the Indian policies have a focus of inclusive development through its Inclusive Innovation Fund.

Major innovative cities in the PRC and India have dominated innovation activities of their respective countries, reflected by USPTO patent data. Furthermore, while major innovative Chinese cities are located all in eastern region, innovative Indian cities have a much even geographic distribution. Finally, while the PRC's innovation has depended on both domestic organizations and MNCs, India relied mostly on MNCs.

REFERENCES

- 2thinknow. (2015). *Innovation City Index*. Available at <http://www.innovation-cities.com/indexes>. Last accessed on 21 November 2015.
- Abhyankar, R. (2014). The government of India's Role in promoting innovation through policy initiatives for entrepreneurship development. *Technology Innovation Management Review*, 4(8).
- Altenburg, T., Schmitz, H. and Stamm, A. (2008). Breakthrough? China's and India's transition from production to innovation. *World Development*, 36(2), 325–344.
- Amiti, M. and Freund, C. (2010). An anatomy of China's export growth? In R.C. Feenstra and S. Wei (eds), *China's Growing Role in World Trade*. Chicago: The University of Chicago Press.
- Amsden, A. H. (1989). *Asia's next giant: South Korea and late industrialization*. Oxford University Press.
- Audretsch, D. B., and Feldman, M. P. (2004). Knowledge spillovers and the geography of innovation. *Handbook of regional and urban economics*, 4, 2713–2739.
- Basberg, B. L. (1987). Patents and the measurement of technological change: a survey of the literature. *Research policy*, 16(2), 131–141.
- Berger, B. and Martin, R.F. (2013). The Chinese export boom: an examination of the detailed trade data. *China & World Economy*, 21(1): 64–90.
- Corey, K. E., Wilson, M. I., and Fan, P. (2014). Cities, Technology, and Economic Change. In Ronnan Paddison and Tom Hutton (eds) *Cities and Economic Change*. Sage Publications Ltd. Chapter 1.
- Fan, P. (2011a). China and India: innovation capability and economic development. *Economic Change and Restructuring*, 44(1–2), 49–73.
- . (2011b). Innovation, globalization, and catch-up of latecomers: cases of Chinese telecom firms. *Environment and Planning, A* 43(4): 830–849.
- . (2014). Innovation in China. *Journal of Economic Surveys*, 28(4), 725–745.
- Fan, P. and Watanabe, C. (2006). Promoting industrial development through technology policy: lessons from Japan and China. *Technology in Society*, 28(3): 303–320.
- Feenstra, R.C. and Wei, S. (eds). (2010). *China's Growing Role in World Trade*. Chicago: The University of Chicago Press.
- Florida, R. L. (2002). *The Rise of the Creative Class: and How It's Transforming Work, Leisure, Community and Everyday Life*. New York: Basic books.
- Freeman, C. (1987). *Technology Policy and Economic Performance: Lessons from Japan*. London: Pinter Publishers.
- . (1995). The 'National System of Innovation' in historical perspective. *Cambridge Journal of Economics*, 19(1), 5–24.
- Government of India. (2012). National Policy on Information Technology, 2012. New Delhi: Government of India. Available at http://meity.gov.in/writereaddata/files/National_20IT_20Policyt%20_20.pdf

- Griffith, R., Redding, S., and Van Reenen, J. (2004). Mapping the two faces of R&D: productivity growth in a panel of OECD industries. *Review of Economics and Statistics*, 86(4), 883-895.
- Griliches, Z (1998). *R&D and productivity: the econometric evidence*. Chicago: University of Chicago Press.
- . (1986). *Productivity, R&D, and basic research at the firm level in the 1970s* (No. w1547). *American Economic Review*, 6:141-154
- . (1990). Patent Statistics as Economic Indicators. *Journal of Economic Literature*, 28, 1661-1707.
- Griliches, Z. (Ed.). (1984). *R&D, patents and productivity*. Chicago: University of Chicago Press.
- Griliches, Z., and Mairesse J. (1984) Productivity and R&D at the firm level. In: Griliches Z (ed) *R&D, patents, and productivity*. Chicago: University of Chicago Press, 339–374.
- Gu, S. (1999) *China's Industrial Technology*. Tokyo: United Nations University Press.
- Hagedoorn, J., and Cloudt, M. (2003). Measuring innovative performance: is there an advantage in using multiple indicators? *Research policy*, 32(8), 1365–1379.
- Johnson, C. (1982). *MITI and the Japanese miracle: the growth of industrial policy: 1925–1975*. Stanford University Press.
- Katrak, H. (1998). Economic analyses of industrial research institutes in developing countries: the Indian experience. *Research Policy*, 27(4), 337–347.
- Kumar, V., and Jain, P. K. (2003). Commercialization of new technologies in India: an empirical study of perceptions of technology institutions. *Technovation*, 23(2), 113–120.
- Lal, D. (1995). India and China: Contrasts in economic liberalization? *World Development*, 23(9), 1475–1494.
- Liu, X. and White, S. (2001) Comparing innovation systems: a framework and application to China's transition context. *Research Policy*, 30(7), 1091–1114.
- Lucas, R. E. (1988). On the mechanics of economic development. *Journal of monetary economics*, 22(1), 3–42.
- Lundvall, B.-A. (ed) (1992) *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*. London: Pinter Publishers.
- Mani, S. (2004). Institutional support for investment in domestic technologies: An analysis of the role of government in India. *Technological Forecasting and Social Change*, 71(8), 855–863.
- Mansfield, E. (1986). Patents and innovation: an empirical study. *Management Science*, 32(2), 173–181.
- Motohashi, K. and Yun, X. (2007). China's innovation system reform and growing industry and science linkages. *Research Policy*, 36, 1431–1442.
- National Statistical Bureau (2005). *China Statistical Yearbook 2005*. Beijing, PRC: National Statistical Bureau.
- Nelson, R.R. (ed) (1993). *National Systems of Innovation: A Comparative Study*. New York: Oxford University Press.

- Petrella, R. (1995). A global agora vs. gated city-regions. *New Perspectives Quarterly*, 12(1), 21–22.
- Radjou, N., Prabhu, J., and Ahuja, S. (2012). *Jugaad innovation: Think frugal, be flexible, generate breakthrough growth*. Hoboken, NJ: John Wiley & Sons.
- Ramani, Shyama V (ed.) (2014). Innovation in India. *Innovation in India: Combining Economic Growth with Inclusive Development*. Cambridge, UK: Cambridge University Press.
- Romer, P. (1990). Endogenous technological change. *Journal of Political Economy*, 98, S71–S102.
- Romer, P. M. (1986). Increasing returns and long-run growth. *Journal of Political Economy*, 1986, 1002–1037.
- Santos-Paulino, A. U., Squicciarini, M., and Fan, P. (2014). Foreign Direct Investment, R&D Mobility and the New Economic Geography: A Survey. *The World Economy*, 37(12), 1692-1715.
- Scott, A. J. (2000). *The Cultural Economy of Cities: Essays on the Geography of Image-Producing Industries*. Thousand Oaks, CA: Sage Publications.
- Sikka, P. (1998). Analysis of in-house R&D centres of innovative firms in India. *Research Policy*, 27(4), 429–433.
- Singh, M. G., Gambhir, A. N. U. R. A. J., and Dasgupta, J. (2011). Innovation in India: affordable innovations. In Dutta, S. (ed) *The Global Innovation Index 2011*. Fontainebleau, France: INSEAD, chapter 3, pp.77–86.
- Wang, Z. and Wei, S. (2010) What accounts for the rising sophistication of China's export? In R.C. Feenstra and S. Wei (eds), *China's Growing Role in World Trade*. Chicago: The University of Chicago Press.
- World Bank. (2006). *World Development Indicators 2006*. Washington, DC: World Bank.
- . (2013). *World Development Indicators 2013*. Washington, DC: World Bank.
- . (2015). *World Development Indicators 2015*. Washington, DC: World Bank.
- Xue, L. (1997) A historical perspective of China's innovation system reform: a case study. *Journal of Engineering and Technology Management* 14(2): 67–81.