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Intellectual Property and Innovation: A Case Study of High-Tech Industries in China

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INTRODUCTION

China set a goal in its *Medium and Long Term National Plan for Science and Technology Development* to "noticeably enhance indigenous innovation capability . . . and join the ranks of innovative countries" by the year 2020.[1] To achieve this goal, China aims to rank top five in the world in patent filing among other strategic goals such as raising research and development (R&D) expenditures to 2.5 % of the GDP and reducing dependence on imported technology to 30%.[2] The Chinese government has also identified several strategic emerging industries that are key targets for state support in stimulating independent innovation capacity. These industries and their projects are mostly knowledge-based, such as "National Broadband Internet Agenda, cloud computing, the Internet of Things, integrated circuits, flat-panel displays, space infrastructure, regional aircraft and industrialization of general aviation aircraft, as well as major application and demonstration projects on the health of the people and on using information technology to benefit the people."[3] The *Report on China's Economic, Social Development Plan (2011)* proclaims:

> We will increase spending on R&D as a percentage of GDP to 1.85%; make positive progress in fostering strategic emerging industries and accelerate development of the service sector; achieve new results in technological upgrading, elimination of backward production facilities, and SOE mergers and reorganizations; reduce energy consumption per unit of GDP by 3.5% compared to last year, reduce the intensity of carbon dioxide emissions by about 3.5%, and cut the four major pollutant indexes—chemical oxygen demand, total ammonia nitrogen and emissions of sulfur dioxide and nitrogen oxide—each by 1.5%; further strengthen ecological

1 THE STATE COUNCIL OF THE PRC, *National Medium- and Long-Term Program for Science and Technology Development of China (2006–2020)*, II-2, *available at* http://english.wzkj.gov.cn/program/program_detail.aspx?id=1.

2 *Id.*

3 *Report on China's Economic, Social Development Plan (2011)*, GOV.CN, http://english.gov.cn/official/2011-03/17/content_1826561_11.htm.

> and environmental improvement; and raise the urbanization level to 48.3%.[4]

It is thus obvious that the Chinese government recognized the importance of developing knowledge-based industries in the global competition and the role of intellectual property (IP) in stimulating innovation in these industries. The question is, however, whether intellectual property rights (IPRs) can really prompt innovation, or more specifically, whether more patents means more innovations. This question has been asked for more than a century and the answer is still far from clear. People in different historical eras, countries, interest groups, academic disciplines, and ideological camps have come up with different conclusions. Much theoretical and empirical research has been devoted to proving their views. This paper will not attempt to reach a conclusion of any sort, but rather, it intends to continue the endeavor of my predecessors in finding empirical evidence of the relationship, if any, between IP and innovation. China is at the turning point from a developing country to a developed country, and from an imitation-oriented country to an innovation-oriented country. Findings from the study of the relationship between IP and innovation of Chinese industries will provide added value to the existing evidence and debates.

Before embarking on the task of finding IP's impact on innovation of Chinese industries, we first define the meaning of innovation so that we know clearly the scope and context of innovation when we assess the impact of IPRs. Some people may perceive innovation and invention as the same thing; therefore defining innovation as the discovery of new ideas in a laboratory, publication of research papers, and filing patents for these inventions. For those people, the more ideas generated, published, and patented means more innovation. However, according to the definition provided by BusinessDictionary.com, an invention is a:

> New scientific or technical idea, and the means of its embodiment or accomplishment. To be patentable, an invention must be novel, have utility, and be non-obvious. To be called an invention, an idea only needs to be proven as workable. But to be called an innovation, it must also be replicable at an economical cost, and must satisfy a specific need. That's why only a few inventions lead to innovations because not all of them are economically feasible.[5]

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4 *Id.* at Pt. II.

5 *Invention Definition*, BUSINESSDICTIONARY.COM, http://www.businessdictionary.com/definition/invention.html (last visited Sept. 2, 2011).

Typically, innovation "involves a multifaceted effort: the discovery, development, improvement and commercialization of new processes and products."[6] These definitions indicate that invention involves only early stages of innovation; that is, the discovery and generation of new ideas including obtaining patents. Innovation, however, entails two or more stages following the invention stage and focusing on the commercialization of inventions. In fact, commercialization is a crucial stage for innovation, without which most inventions "[d]ie a lonely death, never seeing the light of commercial success."[7] The number of patents represents how many inventions have been generated, not how innovative a country is. Patents are important for innovation because they are crucial for further commercialization in some technology sectors, but they are not the sole indicator of innovation. It follows that when we assess the role of IPRs in innovation, we shall not only count how many patents have been filed or granted in a particular country, but we shall also evaluate how many of the patented technologies have been commercialized.

Based on the above definitions, the discussion of the relationship between IP and innovation in Chinese industries will focus not only on how many patents have been filed and granted, but also on how the patented technologies have been developed, transferred, licensed, manufactured, and marketed. This approach will be used in the investigation of all the industries we cover in this paper including biotechnology, pharmaceutical, computer software, telecommunications, automobile, and green technology. These are IP-intensive high-tech industries, and the success of their R&D and commercialization may be closely related to, or largely depended, on the acquisition, commercialization and exploitation of IPRs.

Before investigating how patents affect innovation in the identified Chinese high-tech industries, a survey of literature on the debate about the relationship between IP and innovation is necessary to provide a historical and theoretical background.

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6 Marshall Leaffer, *Patent Misuse and Innovation*, 10 J. HIGH TECH. L. 142, 142 (2010); *See generally* Richard R. Nelson & Sidney G. Winter, AN EVOLUTIONARY THEORY OF ECONOMIC CHANGE (1982).

7 Jeffrey L. Brandt, *Capturing Innovation: Turning Intellectual Assets into Business Assets*, *in* FROM IDEAS TO ASSETS: INVESTING WISELY IN INTELLECTUAL PROPERTY 65 (Bruce Berman ed., 2002).

I
INTELLECTUAL PROPERTY AND INNOVATION: EVIDENCES AND DEBATES

A. IP: Incentive or Impediment in Innovation?

1. Justifications for the Creation and Existence of IPRs

Since the birth of the IP system, various theories have been developed to justify its existence.[8] For example, natural right theory justifies IPRs as a man's natural property right in his own idea which is exclusive and inalienable; labor theory justifies IPRs as a reward for the labor invested by the inventor in his invention; personality theory justifies IPRs as personhood of the inventor; and utilitarian theory justifies IPRs as incentives for innovation.[9] Essentially, these theories recognize the human nature to own, to be rewarded for what they create, and to be incentivized for further creation. A group of economists advance these theories further to analyze how and to what extent this incentive works to foster innovation in the context of economic analysis. For example, in 1962, Kenneth Arrow argued that knowledge has become a "good" when it is assimilated as information, and hence is subject to property ownership. However, the "indivisible" nature of knowledge creates a "free-rider" phenomenon; that is, while the first creator of a certain technology has to invest a huge amount of financial and human resources, the subsequent production may cost very little or nothing at all. This leads to "underinvestment" in knowledge production because no one is willing to become the first inventor.[10] This phenomenon finally results in a "waiting game"[11] and, in the end, "society at large will suffer."[12]

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8 The discussion that follows is largely based on sections 2.1 and 2.2 of my book; Yahong Li, IMITATION TO INNOVATION IN CHINA: THE ROLE OF PATENTS IN BIOTECHNOLOGY AND PHARMACEUTICAL INDUSTRIES 8–17 (Edward Elgar ed., 2010).

9 *See generally* William Fisher, *Theories of Intellectual Property*, *in* NEW ESSAYS IN THE LEGAL AND POLITICAL THEORY OF PROPERTY 168, (Stephen R. Munzer ed., 2001).

10 Kenneth J. Arrow, *Economic Welfare and the Allocation of Resources for Invention*, *in* THE RATE AND DIRECTION OF INVENTIVE ACTIVITY: ECONOMIC AND SOCIAL FACTORS 609, 609–26 (NAT'L BUREAU OF ECON. RESEARCH, 1962).

11 Ove Granstrand, *Innovation and Intellectual Property* (2002), http://www.druid.dk/conferences/summer2003/Papers/GRANDSTRAND.pdf.

12 William Fisher, *Intellectual Property and Innovation: Theoretical, Empirical, and Historical Perspectives*, *in* INDUSTRIAL PROPERTY, INNOVATION, AND THE KNOWLEDGE-BASED ECONOMY 2, 2 (Anthony Arundel ed., 2001).

This view was echoed by Landes and Posner in their economic analysis of copyright and innovation.[13] The problem of "under-investment" in the initial innovation stage may be remedied by competition, by some inventors' pure satisfaction from scientific discovery, and their desire for fame and social recognition rather than monetary rewards.[14] But Arrow concluded that the market itself is incapable of solving the "free-rider" problem, and certain "institutional arrangements" have to be put in place.[15] William Fisher identified five strategies, or institutional arrangements, employed by national governments: (1) governments engage in technological innovation themselves (e.g., in national defense); (2) governments subsidize private sectors' innovation activities (e.g., grants from the National Endowment for the Arts to artists in the United States); (3) governments issue post-hoc prizes or rewards to innovators; (4) governments enact trade secret laws to help increase innovators' competitive advantages; (5) governments confer IPRs on innovators.[16] Other scholars have produced similar lists.[17] It is thus clear that the IP system is an institutional arrangement that was created to remedy the "market failure" in solving the "free-rider" problem and to foster innovation, as indicated by the title of the Statute of Anne (1710); "An Act for the Encouragement of Learning, by Vesting the Copies of Printed Books in the Authors or Purchasers of such Copies, during the Times therein mentioned,"[18] and by Article I of the U.S. Constitution which grants Congress the power "to promote the Progress of Science and useful Arts, by securing for limited Times to Authors and Inventors the exclusive Right to their respective Writings and Discoveries."[19]

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13 William M. Landes & Richard A. Posner, *An Economic Analysis of Copyright Law*, 18 J. LEGAL STUD. 325, 325–33, 344–53 (1989). They wrote, "[w]ithout copyright protection, authors, publishers, and copiers would have inefficient incentives with regard to the timing of various decisions. Publishers, to lengthen their head start, would have a disincentive to engage in prepublication advertising and even to announce publication dates in advance, and copiers would have an incentive to install excessively speedy production lines." *Id.* at 332.

14 Granstrand, *supra* note 11.

15 Arrow, *supra* note 10.

16 Fisher, *supra* note 12, at 2–3.

17 *See, e.g.*, Granstrand, *supra* note 11, at 5.

18 KARL-ERIK TALLMO, THE HISTORY OF COPYRIGHT (forthcoming), *available at* http://www.copywrighthistory.com/anne.html (discussing The Statute of Anne, 1710).

19 U.S. CONST. art I, § 8, cl. 8.

2. IPRs as an Impediment to Innovation

From the above account, we know that the IP system is merely one of many institutional arrangements employed by national governments to promote innovation. But the IP system seems to have received the most skepticism and criticism about its role in innovation. First of all, many scholars questioned whether IPRs could really stimulate innovation at all or to a certain degree. In their work, *The British Patent System*, Boehm and Silberston said that patents were largely irrelevant as a means of inducing inventions, and that some other stimuli "must have been responsible for the inducement of a large body of nineteenth century invention."[20] Ashton, in his 1968 book, *The Industrial Revolution*, and Landes in his 1970 book, *The Unbound Prometheus*, reached a similar conclusion.[21] Eric Schiff studied inventive activity in Switzerland and the Netherlands during the period that the two countries abandoned their patent system and he concludes that the "industrialization of a country can proceed smoothly and vigorously without a national patent system."[22] Blakeney found that the "assumption that patent protection incentivizes innovation has never been convincingly demonstrated, even in industrialized countries, although it underpins the globalized intellectual property regime."[23] Fritz Machlup concluded, "no economist on the basis of present knowledge could possibly state with certainty that the patent system, as it now operates, confers a net benefit or a net loss upon society."[24] Keith Maskus believes that the conclusion that stronger IPRs influence foreign investment, licensing behavior and the transfer of technology can only be tentatively reached because the data and methodology of research to support such a conclusion are very weak.[25]

Other scholars have critiqued that IPRs play a rather negative role in innovation and in social development. For instance, Joseph Stiglitz

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20 KLAUS BOEHM & AUBREY SILBERSTON, THE BRITISH PATENT SYSTEM 37 (1967).

21 T.S. ASHTON, THE INDUSTRIAL REVOLUTION, 1760–1830 (1968); D.S. LANDES, THE UNBOUND PROMETHEUS (1970).

22 ERIC SCHIFF, INDUSTRIALIZATION WITHOUT NATIONAL PATENTS: THE NETHERLANDS, 1869–1912; SWITZERLAND, 1850–1907 124 (1971).

23 Michael Blakeney, *Biotechnological Patenting and Innovation*, *in* PATENTS AND TECHNOLOGICAL PROGRESS IN A GLOBALIZED WORLD 229 (2009).

24 Staff of S. Comm on the Judiciary, 85th Cong., AN ECONOMIC REVIEW OF THE PATENT SYSTEM 79–80 (Comm. Print 1958) (prepared by Fritz Machlup).

25 *See* Keith E. Maskus, TRANSFER OF TECHNOLOGY AND TECHNOLOGICAL CAPACITY BUILDING (2003) (paper presented at the Rockefeller Foundation Bellagio Study, Sept. 18-21, 2003), *available at* www.iprsonline.org/unctadictsd/bellagio/docs/Maskus_Bellagio 2.pdf.

believes that IP regimes stifle science and innovation because they "create monopoly power over knowledge that is often abused."[26] William Fisher pointed out three side effects of IPRs: (1) costly to administer; (2) sometimes impeding cumulative innovation; (3) pricing consumers.[27] Michael Heller and Rebecca Eisenberg concluded that patents for upstream medical research can deter innovation. They wrote that the proliferation of fragmented and overlapping patent rights creates a tragedy of "'anticommons' in which people underuse scarce resources because too many owners can block each other."[28]

3. IPRs as an Incentive to Innovation

On the other hand, many scholars argue that the role of IPRs in innovation is largely positive. For example, John Barton and Ezekiel Emanuel state that the patent is a genius design for the recognition of an inventor's creativity and a means to enhance innovation.[29] Dan Burk and Mark Lemley confirmed that "[p]atent law is [a] primary policy tool to promote innovation, encourage the development of new technologies, and increase the fund of human knowledge."[30] Dutton succinctly summarized the views of some other scholars:

> Holdsworth, for example, claims that during the late seventeenth and eighteenth centuries 'the administration of the law as to the grant of patents . . . was successful in encouraging British industry'. Fox considered that 'it was . . . not by accident that the patent system had its origins in England nor that the Industrial Revolution was the inevitable consequence' . . . . In a much-neglected book Ravenshear argues that 'patents exercised a net influence in stimulating the growth of industry'. For Harding there was 'little doubt that patents helped to create the industrial supremacy which existed at the time of the Great Exhibition'. And Hatfield, writing in a mood of patriotic zeal, concluded that the 'patent law was our

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26 Dugie Standeford, *Intellectual Property Regime Stifles Science and Innovation, Nobel Laureates Say*, INTELLECTUAL PROPERTY WATCH BLOG (July 7, 2008, 12:44 AM), http://www.ip-watch.org/weblog/2008/07/07/intellectual-property-regime-stifles-science-and-innovation-nobel-laureates-say.

27 Fisher, *supra* note 12, at 4.

28 Michael A. Heller & Rebecca S. Eisenberg, *Can Patents Deter Innovation? The Anticommons in Biomedical Research*, 280 SCI. 698, 698 (1998).

29 John H. Barton & Ezekiel J. Emanuel, *The Patents-Based Pharmaceutical Development Process: Rationale, Problems, and Potential Reforms*, 294 JAMA 2075 (2005).

30 Dan L. Burk & Mark A. Lemley, *Policy Levers in Patent Law*, 89 VA. L. REV. 1575, 1576 (2003).

> invention, and it gave us the first place among nations in industry for over 200 years.[31]

In the 1960s, economists focused primarily on the effect of patent term on innovation. In Arrow's analysis, imitation can dwindle innovator's profits; thereby reducing innovator's incentive to invest in R&D. The term of patent protection can deter imitation and thereby incentivize innovation.[32] William Nordhaus found that the increase of patent term could boost incentives for generating innovations.[33] The focus of study shifted in the 1990s from the length of patent protection to the optimal scope of patent protection. The representatives of this trend include Paul Klemperer,[34] Richard Gilbert and Carl Shapiro,[35] and Lerner.[36] Their studies show that the scope of patents can impact patent holders' ability to raise prices on the invention costs and product substitutes. Christine Greenhalgh and Mark Roger list four ways in which IPRs can promote innovation.[37] First, giving people a monopoly on their innovations will further increase the incentive and resources dedicated to innovation. Second, venture capitalists are more willing to fund a project that has patent protection. Third, firms may invest more in R&D using profits gained from IPRs through licensing and various patent strategies. Finally, the early disclosure of patent technology enables the dissemination of technological information. Christopher Kalanje found that IPRs play an indispensible role in every stage of innovation: from the perception of innovative ideas to the marketing of a final product.[38] Specifically, inventors normally must decide to protect their invention either by trade secrets or patents at the first stage of the generation of innovative ideas, then proceed to search and research on patent

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31 H.I. DUTTON, THE PATENT SYSTEM AND INVENTIVE ACTIVITY DURING THE INDUSTRIAL REVOLUTION, 1750–1852 3 (1984) (internal citation omitted).

32 Granstrand, *supra* note 11, at 7.

33 *Id.*

34 Paul Klemperer, *How Broad Should the Scope of Patent Protection Be?*, 21 RAND J. ECON. 113 (1990).

35 Richard Gilbert & Carl Shapiro, *Optimal Patent Length and Breadth*, 21 RAND J. ECON. 106 (1990).

36 Joshua Lerner, *The Importance of Patent Scope: An Empirical Analysis*, 25 RAND J. ECON. 319 (1994).

37 Christine Greenhalgh & Mark Rogers, *The Value of Intellectual Property Rights to Firms and Society*, 23 OXFORD REV. ECON. POL'Y 541 (2007).

38 Christopher M. Kalanje, *Role of Intellectual Property in Innovation and New Product Development*, WORLD INTELL. PROP. ORG., http://www.wipo.int/sme/en/documents/ip_innovation_development.htm (last visited Aug. 5, 2011).

documents, and then file patent applications for their inventions.[39] This is followed by a stage of "IP as Life-Line While Passing Through the 'Valley of Death' of Innovation" during which patents are important to protect know-how when Small and Medium Enterprises (SMEs) use external technology resources, settle IP ownership disputes, find financiers, facilitate sales and licensing, and form joint ventures.[40] The above studies mirror the reasons for supporting the patent system given in the U.S. *Report of the President's Commission on the Patent System 1–3* (1966). The report states:

> Agreeing that the patent system has in the past performed well its Constitutional mandate "to promote the progress of . . . useful arts," the Commission asked itself: What is the basic worth of a patent system in the context of present day conditions? The members of the Commission unanimously agreed that a patent system today is capable of continuing to provide an incentive to research, development, and innovation. They have discovered no practical substitute for the unique service it renders.[41]

The U.K. Commission on Intellectual Property Rights (CIPR) concluded that the demand for IP protection increases when a large share of the industrial base is engaged in innovative activities.[42] The International Chamber of Commerce published a report in 2005 concluding that IP protection correlates with national competitiveness. The report pointed out that, in 2004, the twenty countries with the strongest IP protection were among the top twenty-seven in the World Economic Forum (WEF) Growth Competitiveness Index, while the twenty countries with the weakest IP regimes ranked among the bottom thirty-six for competitiveness.[43]

B. IP and Innovation: Industry Specific Assessment

In addition to the above two contrary views, some scholars believe that the role of patents in innovation varies by context. Specifically, they argue that the role of patents is specific to certain industrial sectors, types of technology, and stages of innovation. Bronwyn Hall

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39 *Id.*

40 *Id.*

41 S. Res. 52, 90th Cong. (1967).

42 *See generally* COMM'N ON INTELLECTUAL PROP. RIGHTS, INTEGRATING INTELLECTUAL PROPERTY RIGHTS AND DEVELOPMENT POLICY (2002).

43 INT'L CHAMBER OF COMMERCE, INTELLECTUAL PROPERTY: SOURCE OF INNOVATION, CREATIVITY, GROWTH AND PROGRESS 7 (2005).

provided theoretical and empirical evidence on this finding.[44] According to Hall some earlier studies show that when patents are granted to single products or pieces of knowledge, it is almost certain that the patent will encourage innovation. In some instances, the patent may produce "too much" innovation.[45] Yet when the patent involves multiple products, many pieces of knowledge or multiple stages of research (such as "research tools" in upstream medical research and downstream drug discovery), or the innovation is sequential or cumulative, then the role of patents in innovation may be positive in some contexts but negative in others. James Bessen and Eric Maskin conclude that there are more innovations without patents in sequential cases.[46] Others found that patents are only positively associated with innovation in the pharmaceutical, biotechnology, and medical instrument areas.[47] The U.K.'s Commission on IPRs concluded that patents are essential to innovation in the biotechnology, pharmaceutical, chemical, petroleum, and some components of IT industries.[48]

Particularly in the biotechnology and pharmaceutical industries, patents are considered important for new spin-off and start-up enterprises to attract capital investments and to be used as negotiating tools in joint ventures and alliances. A survey conducted by the Berkeley Center for Law and Technology (BCLT) in 2008 on high technology startup firms in the United States shows that, for the biotechnology industry, patents are ranked the most important factor for capturing competitive advantage.[49] "Even public research organizations are placing more strategic value on patenting," said a report written by a group of researchers from the Canadian Program on Genomics and Global Health.[50] Jasemine Chambers compares the

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44 Bronwyn H. Hall, *Patents and Patent Policy*, 23 OXFORD REV. ECON. POL'Y 568 (2007).

45 *Id.* at 573.

46 James Bessen & Eric Maskin, *Sequential Innovation, Patents, and Imitation*, 40 RAND J. ECON. 611 (2009).

47 *See, e.g.*, Edwin Mansfield, *Patents and Innovation: An Empirical Study*, 32 MGMT. SCI. 173 (1986); Richard C. Levin et al., *Appropriating the Returns from Industrial R & D* 1987 BROOKINGS PAPERS ON ECON. ACTIVITY 783 (1987); Wesley M. Cohen et al., *R&D Spillovers, Patents and the Incentives to Innovate in Japan and the United States*, 31 RES. POL'Y 1349 (2002).

48 *See supra* note 42.

49 Stuart J.H. Graham et al., *High Technology Entrepreneurs and the Patent System: Results of the 2008 Berkeley Patent Survey*, 24 BERKELEY TECH. L.J. 1255, 1262 (2009).

50 Uyen Quach et al., *Biotechnology Patenting Takes Off in Developing Countries*, 8 INT'L J. BIOTECHNOLOGY. 43, 45 (2006).

biotechnology patenting regimes in the United States, Europe, and Japan, and reaches the conclusion that:

> The United States has capitalized its strong biotechnology research base and broad concepts of patent-eligible subject matter to lead the world in biotechnological research and development . . . . Just as developing countries can accrue a temporary free-rider advantage by providing minimal patent protection, Europe and Japan have limited their patent protection in those biotechnological areas that trail the United States. While such limited patent protection provides short-term benefits, it also runs the risk of locking Europe and Japan into long-term position of technological inferiority by failing to adequately protect research and development investments in biotechnology.[51]

Patents are considered particularly important for pharmaceutical R&D, as it involves eight to twelve years of clinical trials, regulatory approval, and $500 to $800 million. Without patents to enable firms to recoup their investment, it is almost certain that few firms would be willing or able to engage in any drug discovery. In the words of the Rt. Hon. Sir Robin Jacob, a Judge of the Court of Appeals of England and Wales in charge of the Intellectual Property List:

> It is the patent system, which has made the advances in medicines possible. Although economists sometimes debate whether the patent system is useful generally, no one has ever seriously challenged its place for medicines. And that is because it is so obvious that without a reliable patent monopoly there is simply no incentive to invest.[52]

However, as mentioned above, Heller and Eisenberg argued that patents for upstream medical research could deter innovation and create "tragedy of the anticommons."[53] Based on the studies of genomic diagnostics, John Barton discovered that patents for devices such as the oligonucleotide chip, which is used for sequencing, seeking mutations, testing pathogens to evaluate different forms of drug resistance, and testing cancer cells to determine the specific mutation involved, "raise no problem of excluding others from detecting the same mutations in different ways; they almost certainly

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51 Jasemine Chambers, *Patent Eligibility of Biotechnological Inventions in the United States, Europe, and Japan: How Much Patent Policy is Public Policy?*, 34 GEO. WASH. INT'L L. REV. 223, 245–46 (2002).

52 The Rt. Hon. Sir Robin Jacob, Patents and Pharmaceuticals—a Paper Given on 29th November at the Presentation of the Directorate-General of Competition's Preliminary Report of the Pharma-Sector Inquiry (Nov. 29, 2008) (*available at* http://ec.europa.eu/competition/sectors/pharmaceuticals/inquiry/jacob.pdf).

53 Heller & Eisenberg, *supra* note 28.

serve as useful incentives to develop new technologies."[54] But patents for "the use of a specific gene sequence to identify a specific biological property (that is, patents on specific diagnostic sequences or on pathogen or cancer-related mutations) pose a particular problem," because "they may make it difficult for the integrator of a microarray/chip device to assemble the rights to use the different patented sequences that are relevant to a clinical or research application."[55]

Patents are equally important in innovation for hardware companies including medical hardware, such as surgical devices, and IT hardware, such as computers and semiconductors.[56] But they are less important for software firms.[57] The 2008 Berkeley Patent Survey shows that two-thirds of about 700 surveyed software firms report that they neither have, nor are seeking patents for their inventions, and they rate patents as the least important tools among seven options for attaining a competitive advantage in the marketplace. Even software startups consider patents as an insignificant incentive to invest in innovation.[58] Among all the factors affecting the firms' decision not to obtain patents, cost stands out as the number one factor. About forty percent of the firms surveyed reported that the costs for obtaining and enforcing patents were the most important factor in their decision to forego patents, while more than forty percent cited the unpatentability of the invention as a factor.[59]

Due to the diverse role of patents among various technologies, scholars have developed theories about whether a patent right (or how much of a patent right) should be given to inventions produced in different industrial sectors and stages of research. In 1977, a "prospect theory" was developed by Edmund Kitch, who argued that patents encourage further commercialization and more efficient use of unrealized ideas, just as a "prospect" system encourages a landowner to make efficient use of his or her private land. As such, strong rights should be given to a single entrepreneur. The "patents should be broad, stand alone, and confer almost total control over subsequent

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54 John H. Barton, *Emerging Patent Issues in Genomic Diagnostics*, 24 NATURE BIOTECHNOLOGY 939, 939 (2006).

55 *Id.*

56 Stuart J.H. Graham et al., *supra* note 49, at 1262.

57 *Id.*

58 Pamela Samuelson, *Why Software Startups Decide to Patent . . . Or Not: Berkeley Patent Survey Finds First-Mover Advantage Trumps Patents for Some*, O'REILLY RADAR (July 21, 2010), http://radar.oreilly.com/2010/07/why-software-startups-decide-t.html.

59 *Id.*

uses of the product."[60] In 1990, the theory of "tailored incentives" was developed by Robert Merges and Richard Nelson based on the "cumulative innovation" model. According to this theory, since innovations are cumulative, patent rights should be granted to both the initial inventor and subsequent improvers so that an incentive to innovate can be fairly maintained.[61] In 1998, an "anticommons" theory emerged to adjust the "tailored incentives" theory by pointing out that patents that horizontally cover different species, as well as vertically protecting different steps, will render resources in the commons underused because patent owners can block each other. To solve this problem, the patents should either be consolidated into a single hand, or be eliminated altogether for certain types of innovations, for example, upstream research tools.[62] Barton also proposed two possible ways to limit patent rights to diagnostic sequences; one is to reject patent coverage, and another is to require patentees to grant reasonable royalty licenses for use of the sequence as a part of an array, or for use of the sequence in pharmacogenetics.[63]

Building on the above theories, Dan Burk and Mark Lemley proposed an "industry-specific" theory to see how these theories best fit various industries so that the role of patents in innovation can be maximized.[64] They found that industries vary greatly in terms of innovation, and each of the above theories may fit better in one kind of industry but not another. For example, "cumulative innovation theory" fits best in business methods, software, and, arguably, Internet industries, while "prospect theory" fits best with the pharmaceutical industry. Specifically, "prospect theory" can be used to justify strong and broad patent rights granted to the initial inventors in the pharmaceutical industry because: (1) the pharmaceutical industry normally has long development and testing lead times; (2) it is very expensive to innovate, costing as much as $800 million on R&D for each new drug; (3) its products are easy to imitate, and generic producers can avoid R&D costs entirely; (4) if a patent does not cover a group of related products, imitators can easily design around the patent by using a close chemical analog; and (5) much of the work occurs after the drug is first identified, so it is important to

60 Burk & Lemley, *supra* note 30, at 1615-16.

61 Robert P. Merges & Richard R. Nelson, *On the Complex Economics of Patent Scope*, 90 COLUM. L. REV. 839 (1990).

62 Heller & Eisenberg, *supra* note 28, at 698.

63 Barton & Ezekiel, *supra* note 54.

64 Burk & Lemley, *supra* note 30, at 1578.

give patentees the right to coordinate downstream changes to the drug.

In the same vein, "anti-commons theory" can also be used to support strong and concentrated patent rights in the biotechnology industry because, as in the pharmaceutical industry, biotechnology is a high-cost and high-risk industry. But on the other hand, attention has to be paid to the "anti-commons" problem caused by patenting upstream research tools. Based on these analyses, Burk and Lemley concluded that patent law should not be uniformly applied across different industries; instead, courts should apply various policy levers of patent law to accommodate the specific nature of different technologies and industries. For example, within the pharmaceutical industry, fewer and broader patents should be granted with more relaxed disclosure requirements and strengthened doctrines of equivalents. Within the biotechnology industry, there should likewise be fewer and broader patents with more relaxed written enablement requirements, as well as strengthened doctrines of equivalents and experimental use exceptions.

C. IP and Innovation: Country Specific Assessment

1. The United States

The United States is arguably the most innovative country in the world; it is therefore helpful to investigate how intellectual property rights affect innovation in this country. It is commonly known that the United States is responsible for many of the world's modern inventions, including electricity, penicillin, the printing press, the car, the telephone, the airplane, the computer, the camera, eyeglasses, cotton gin, metal cans for food, the iPod, the Internet, etc.[65] At the same time, the United States is also a leader in patenting. In the 1980s, the annual patents filed in the United States numbered about 60,000, and this number was increased to 150,000 by the late 1990s.[66] Between 1990 and 2000, the number of granted patents doubled in the biotechnology and computer sectors.[67] The top 100 U.S. universities tripled their annual patent output from 1984 to 1994.[68] Of course, there are many factors contributing to the United States' leading

65 *See generally* RUTH SCHWARTZ COWAN, A SOCIAL HISTORY OF AMERICAN TECHNOLOGY (1997)

66 Nancy T. Gallini, *The Economics of Patents: Lessons from Recent U.S. Patent Reform*, 16 J. OF ECON. PERSP. 131, 131 (2002).

67 *Id.*

68 *Id.*

position in innovation, such as a better education system and more talented people, more investment in innovation and good innovation policies, and so on. However, from the perspective of law and economics, it is not a coincidence that the United States tops the world on both innovation and patents.

Although patents are one of the indicators of innovation, the sheer number of patents does not explain why the United States has obtained its leading position in innovation. As we mentioned in the beginning of this paper, the number of patents can represent the number of inventions generated, but innovation involves multifaceted efforts in commercialization of patented technologies. Compared with other countries, the United States' governmental policies and patent system are much more focused on fostering commercialization of patented technologies. Its patent system, including patent legislation, prosecution, litigation, and management, is designed to be pro-innovation. First of all, U.S. patent law covers the broadest patentable subject matter, to allow newly emerged technologies to be patented. U.S. patent law provides that "Whoever invents or discovers any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof, may obtain a patent therefore, subject to the conditions and requirements of this title."[69] Under this provision, anyone who "discovers," not merely "invents," new and useful products and processes can obtain a patent. Although the distinction between "discovery" and "invention" is not clearly made, the former normally refers to findings from nature without much human intervention, and the latter refers to something generated by humans in a laboratory. While patent laws of other jurisdictions exclude "discoveries" from patentable subject matter almost without exception, the U.S. patent law arguably allows "discovery" to be patentable. This opens the door for patents on microorganisms, genes, plants, etc. In addition, unlike other jurisdictions that negatively exclude many subject matters from patentability, U.S. patent law positively lists patentable subject matter without any explicit exclusion. The patentable subject matters cover four broad areas including process, machine, manufacture or composition of matter, and improvement, so that many inventions can be interpreted as patentable inventions.[70] For example, pharmaceuticals and chemical substances can be patented as composition of matter. Furthermore, under U.S. patent law's utility requirement, a new invention is

69 35 U.S.C. § 101 (2010).

70 *Id.*

patentable as long as it is "useful."[71] The law does not require it to be industrially applicable, to be moral, and to produce positive effects as required under the patent laws of many other jurisdictions. Therefore, some inventions whose utility was unidentifiable at the time of discovery (e.g., CCR5 receptor gene),[72] and some considered patentable living matters in the past (e.g., onco-mouse) have been patented.[73]

Case law has further broadened the patentable subject matter. For example, under the Supreme Court's ruling in *Diamond v. Chakrabarty*, "anything under the sun that is made by man" is patentable.[74] And a series of other court decisions such as *Diamond v. Diehr*[75] and *State Street Bank v. Signature*[76] expanded patent subject matter to include software and business methods.

Second, the United States adopts an inventor-friendly patent prosecution process. Until recently, the United States has been the only country using the "first-to-invent" approach in the patent filing system. It has been argued that this system is beneficial to small businesses and individual inventors who do not have sufficient resources to race to the U.S. Patent and Trademark Office (USPTO), and that the pending amendment to change it to a "first-to-file" system will kill U.S. innovation.[77] Another distinctive feature of the U.S. patent prosecution system is the "one-year grace period," which allows inventors to file patents one year after their inventions have been disclosed.[78] This regime arguably provides an incentive for early

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71 *Id.*

72 Human Genome Sciences Inc. (HGS) of Rockville, Maryland, was awarded a patent for CCR5 receptor gene in February 2000. When the patent application was filed, the specific function of the protein of CCR5 gene was not disclosed. It was only discovered later that CCR5 works as a co-receptor in binding HIV. *See The Fate of Gene Patents Under the New Utility Guidelines*, 2001 DUKE L. & TECH. REV. 0008 (2001).

73 Oncomouse was patented in 1988 by Harvard College. It is also called "Harvard Oncomouse." Specifically, the mouse is injected with an activated oncogene which makes the mouse more susceptible to cancer so that it can be used for cancer research. *See Bioethics and Patent Law: The case of the Oncomouse*, WIPO MAGAZINE, http://www.wipo.int /wipo_magazine/en/2006/03/article_0006.html.

74 Diamond v. Chakrabarty, 447 U.S. 303, 309 (1980).

75 Diamond v. Diehr, 450 U.S. 175 (1981).

76 State St. Bank and Trust Co. v. Signature Fin. Grp., Inc., 149 F.3d 1368 (Fed. Cir. 1998).

77 Grace Wyler, *Is Congress Trying To Kill American Innovation Through Patent Reform?* BUSINESS INSIDER, http://www.businessinsider.com/is-congress-trying-to-kill-american-innovation-through-patent-reform-2011-5.

78 35 U.S.C. 102(b) (2002) provides that "A person shall be entitled to a patent unless—(b) the invention was patented or described in a printed publication in this or a

disclosure of new inventions and application for patents. The third unique feature of the U.S. patent prosecution system is its "provisional patent application," which gives inventors additional time to further develop the invention, determine the marketability of the invention, acquire funding, and seek licensing and manufacturing opportunities. Third, the United States has a pro-patentee litigation system. Between 1982 and 1990, the Court of Appeals for the Federal Circuits (CAFC) upheld ninety percent of the decisions ruled in favor of the patentee compared with sixty-two percent during 1953–1978, and the Court overturned twenty-eight percent of the decisions ruled in favor of the alleged patent infringers, compared with twelve percent previously, and increased in the granting of preliminary injunctions.[79] The ruling by the Supreme Court in *Festo Corp. v. Shoketsu Kinzoku Kogyo Kabushiki Co.*[80] allowed the flexible application of the "doctrine of equivalents," greatly helped the patentees in their infringement suits.

Lastly, the U.S. Congress passed a series of legislation aimed to foster innovation and IP commercialization. For example, in 1980, the Bayh-Dole Act[81] was passed to allow federally funded research institutions to retain patent rights and to commercialize the inventions through exclusive licensing. In 1984, the Drug Price Competition and Patent Restoration Act, known as "Hatch-Waxman Act,"[82] was passed to restore up to five years of lost patent time on clinical trails and FDA approval. In 1986, the Federal Technology Transfer Act[83] was passed to make technology transfer a responsibility and a promotional criterion for federal laboratory scientists and engineers. And in 1999, the American Inventors Protection Act[84] was passed to require the publication of patent applications eighteen months from the first filing so that the public can benefit from the earlier disclosure of patented information.

While a pro-innovation patent system has a very positive effect on promoting innovation in the United States, but it has also produced some unintended side effects. For example, increasing patent filing

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foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States."

79 Gallini, *supra* note 66, at 134.

80 Festo Corp. v. Shoketsu Kinzoku Kogyo Kabushiki Co., 553 U.S. 722 (2002).

81 U.S. Patent and Trademark Law Amendments Act of 1980, 35 U.S.C. 200-12 (1980).

82 Drug Price Competition and Patent Term Restoration Act of 1984, Pub. L. No. 98-417 (1984).

83 Federal Technology Transfer Act of 1986 (FTTA) Pub. L., No. 99-502 (1986).

84 American Inventors Protection Act, Pub. L., No. 106-113 (1999).

has created a backlog of 1.2 million non-provisional patent applications, which may result in poor patent examination quality, ultimately leading to many bad patents. There are also increasing complaints about the rise of the patent trolls, escalating damage awards, and antitrust disputes.

2. IP and Innovation in Developing Countries

The above theories are largely focused on industrialized countries. Though disputed, the role of IP in developed countries is generally viewed as necessary and positive, with some disagreement on exactly how important the patent is in different industrial sectors. The role of IP in developing countries, on the other hand, has generally been perceived as insignificant or irrelevant in promoting innovation. For example, a study concludes that, "by far the most efficient way for developing countries (and also industrialized countries) of encouraging the production of new technology is an increase in education in the technical and science field and not a law on the protection of inventions."[85] Carlos Primo Braga found "there is very little empirical evidence of the impact of stronger intellectual property protection on domestic R&D in developing countries."[86] Another study found that the strength of IPRs is positively associated with R&D investment in countries with above-median income, but not for less-developed countries.[87] The U.K. Commission on Intellectual Property Rights reached similar conclusion in its report:

> [F]or most developing countries with weak technological capacity, the evidence on trade, foreign investment, and growth suggests IP protection will have little impact . . . For more technologically advanced developing countries, the balance is finer. Dynamic gains may be achieved through IP protection, but at costs to other industries and consumers.[88]

However, more recent studies, particularly in biotechnology area, have found that the connection between IP and innovation does exist in developing countries. In a study on genomic medicine in Mexico,

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85 H.E. Grundmann, *The Economic Arguments for Patents and Their Validity for Developing Countries*, 19 INDIAN ECON. J.193, 198 (1970).

86 Carlos Primo Braga, *The Developing Country Case for and Against Intellectual Property Protection*, *in* STRENGTHENING PROTECTION OF INTELLECTUAL PROPERTY IN DEVELOPING COUNTRIES: A SURVEY OF THE LITERATURE 69, 80 (Wolfgang E. Siebeck ed., 1990).

87 Walter G. Park & Juan Carlos Ginarte, *Intellectual Property Rights and Economic Growth*,15 CONTEMP. ECON. POL'Y 51, 60 (1997).

88 INTEGRATING INTELLECTUAL PROPERTY RIGHTS AND DEVELOPMENT POLICY, *supra* note 42, at 4.

India, and Thailand, the researchers identified the inadequacy of existing regulatory and intellectual property regimes in these countries as one of the most significant obstacles to advances in genomics.[89] They further concluded in their report that, "in health biotechnology, intellectual property protection remains a vital factor towards the establishment of a private sector and the commercialization of products in developing countries."[90] Another study examined Brazil's biotech industry and identified an inefficient patenting system as one of the four major barriers to bio-health development. Specifically, Brazilian patent law does not protect some important biotechnologies, such as recombinant version of proteins found in nature, and it takes a very long time (more than seven years) to process patent applications for drug candidates.[91] Furthermore, a study on India's biotechnology industry noted that Indian biotech firms aim to become more competitive by patenting their products and technologies on a global basis.[92] Professor Joseph Straus also attributed the recent growth of India's pharmaceutical sector to a stronger patent regime, which India adopted in compliance with the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS), for example, by achieving TRIPS protection standards in pharmaceutical patent protection.[93]

II
IP AND INNOVATION IN CHINA'S HIGH-TECH INDUSTRIES

We know from the above section that China ranked fourth in the world in Patent Cooperation Treaty (PCT) filings. Next we analyze the application for PCT and other patents by China's different industrial sectors, as well as their IP commercialization. According to a statistic of China's State Intellectual Property Office (SIPO), Chinese enterprises have recognized the importance of, and have become very active in, filing PCT patents, which reflects the trend of China's current economic development. Since 2009, China has replaced Germany as the leading export country, requiring Chinese

89 Béatrice Seguin et al., *Genomic Medicine and Developing Countries: Creating a Room of Their Own*, 9 NATURE REVIEWS 487, 487 (2008).

90 *Id.* at 491.

91 Rahim Rezaie et al., *Brazilian Health Biotech—Fostering Crosstalk Between Public and Private Sectors*, 26 NATURE BIOTECHNOLOGY 627, 638 (2008).

92 Sarah E. Frew et al., *India's Health Biotech Sector at a Crossroads*, 25 NATURE BIOTECHNOLOGY 403, 415 (2007).

93 Joseph Straus, *The Impact of the New World Order on Economic Development: The Role of the Intellectual Property Rights System*, 15 EUROPEAN REV. 47, 47 (2007).

enterprises to increase protection of their technologies in overseas markets. In the meantime, the innovative capability of Chinese enterprises has greatly increased in recent years, further promoting awareness of IPR protection among these enterprises. Accordingly, while PCT applications worldwide declined 4.5% in 2009 due to global financial crisis, China's PCT application scored a 30% increase.[94] Most of these PCT applications came from enterprises (e.g., 60.6% in 2008) that are controlled by private shareholders (e.g., 50%). TABLE 1 below shows that the Chinese PCT filings in 2007–2008 were primarily concentrated in IT (telecommunications equipment, computer and other electronic equipment manufacturing) and medical and pharmaceutical manufacturing areas, counting for 19.5% and 18.1% of all filings in those years.[95] In 2009, Chinese enterprises filed 20% of PCT applications worldwide in the field of telecommunications, and 2.5% in medical and pharmaceutical fields.[96] Two companies, Hauwei and ZTE, have stood out as top PCT filers. Huawei ranked first in 2008 and second in 2009 respectively, and ZTE jumped from twenty-third in 2009 to second in 2010.[97] However, other areas witnessed much less explosive achievements.

The sections that follows will focus on six industries categorized into three groups: (1) Health-related industries (biotechnology and pharmaceuticals), (2) Information technology industries (software and telecommunications), and (3) Environment-related industries (automobile and green-technologies). Each industry will be examined separately, with a brief introduction of their industry and R&D models, and followed by a discussion of their patenting and commercialization status. The categorical analysis of the empirical data and facts should provide a clearer and more objective assessment of the role of that IP plays in Chinese industries.

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94 STATE INTELLECTUAL PROP. OFFICE OF CHINA MGMT. & DEV. BUREAU, *Investigative Report on China's International Patent Applications*, PATENT STATISTIC REPORT, NO. 16, at 2 (2010), http://www.sipo.gov.cn/ghfzs/zltjjb/201008/P020100804354945783145.pdf [hereinafter PATENT STATISTIC REPORT].

95 *Id.* at 4.

96 *Id.*

97 *Id.*

TABLE 1. Enterprises Applying PCT and Domestic Applications (%) in 2007–2008

Industrial Sectors	PCT Filings	Domestic Filings
Telecom manufacturing, computer & other electric manufacturing	19.5%	12.3%
Pharmaceutical manufacturing	18.1%	13.7%
Chemicals and chemical products manufacturing, oil and nuclear fuel processing industry	10.3%	12.8%
Electrical machinery and equipment manufacturing	9.3%	6.9%
Special equipment manufacturing	7.8%	11.4%
Information transmission, computer services and software industry	6.7%	5.7%
Transportation equipment manufacturing	4.5%	4.4%
Metal smelting, rolling and processing industry	4%	6.2%
Handicrafts and other manufacturing	3.6%	3.3%
General equipment manufacturing	3.2%	3.5%

Source: SIPO Patent Statistics Brief Report 2010 (16)

A. Health-Related Industries (Biotechnology and Pharmaceuticals)

1. Industry, Market, and R&D Model

The growth of China's biotech and pharmaceutical industries and market has been remarkable in the past three decades. The Chinese biotech market is projected to reach $9 billion by 2010, and the biotech industry is expected to account for about seven to eight percent of China's GDP by 2020. The Chinese pharmaceutical market is expected to become the world's third largest market by 2011, behind France and Germany, with the sales projected to reach $40 billion by 2013.[98] The innovative capacity of China's biotech and

98 David Campbell & Mandy Chui, *Pharmerging Shake-Up: New Imperatives in a Redefined World*, IMS HEALTH, at *2,*5 (2010), http://www.imshealth.com/deployedfiles/imshealth/Global/Content/StaticFile/Pharma_Shake-up_Imperatives_3_10.pdf.

pharmaceutical industries can be summarized as follows: it is relatively high in the basic research areas such as genomics, proteomics, transgenic plants, animal cloning, and stem cell, the expertise of which "already stands out at the international level."[99] But innovation is fairly low in drug discovery and commercialization for both chemical drugs and traditional Chinese medicines (TCM).[100] It was estimated in 2004 that, of the 1300 synthetic medicines produced by Chinese firms, ninety-seven percent are imitation,[101] and out of more than 1000 companies involving in anti-cancer drug development, ninety-nine percent produce imitated drugs.[102] The imitation rate is even higher in biotechnology, where biogenerics are estimated to make up more than ninety percent of the $3 billion Chinese biopharmaceutical market.[103] The typical R&D models in China's biotech and pharmaceutical industries are "me too" and "me better" which save money and time but involve tremendous technical and legal risks.[104] There are a few successful "me too" or "me better" gene therapy drugs being developed in China. For example, Endostar, H101, and Gendicine were developed based on similar products initially developed in other countries, with some improvements in increasing activation and reducing toxicity.[105]

2. Patentability and Patenting Status

Chinese patent law is a mirror image of the European Patent Convention (EPC) on patentable biotechnology and pharmaceuticals. That is, limitations on patentable subject matter are in a negative list of exclusion, rather than the positive listing used in U.S. patent law. For example, "scientific discoveries", "methods for the diagnosis for treatment of diseases," "animal and plant varieties," and any invention that is against public interest or social morality is excluded from patentable subject matter.[106] Patent Examination Guidelines formulated by SIPO provide further guidance on what is patentable.

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99 CHERI GRACE, THE EFFECT OF CHANGING INTELLECTUAL PROPERTY ON PHARMACEUTICAL INDUSTRY PROSPECTS IN INDIA AND CHINA: CONSIDERATIONS FOR ACCESS TO MEDICINES 43 (2004), *available at* http://www.who.int/hiv/amds/Grace 2China.pdf.

100 Li, *supra* note 8, at 30.

101 CHERI GRACE, *supra* note 99 at 42.

102 X.Q. Wang, *Gold Fever in Anti-Cancer Drugs*, SOUTHERN WEEKEND (China), Oct. 19, 2006, at C18.

103 Li, *supra* note 8, at 53.

104 *Id.* at 53–57.

105 *Id.* at 55.

106 PRC Patent Law art. 5, 25.

Generally, "biological materials per se" (e.g., gene, plasmid, microorganism, and animal or plant cell lines), genetic materials (e.g., DNA, RNA and chromosomes), microorganisms, and chemical substances and pharmaceuticals, as well as processes for producing the above substances, are patentable.[107] The lack of patent protection for animal and plant varieties has been criticized as a major obstacle to China's biotechnology development. Nevertheless, the Chinese Patent Law Article 25 allows the processes used in creating animals and plants to be patented if they are not essentially biological.[108] This has created a "back door" for animal and plant varieties to be patentable.[109] Ultimately, Chinese patent law protects patentable biotechnology and pharmaceutical inventions less broadly than under U.S. patent law, but a broader spectrum of patentable subject matter is available in China thanks to more liberal Examination Guidelines. While it may be appropriate for the current developmental stage of these industries, broader protection may be needed if China wishes to become a leader in these fields.

Even with such obstacles, the increase in biotech and pharmaceutical patenting in China has been remarkable. From 2002 to 2005, the annual rate of increase was 23%. By the end of 2006, the total number of applications for biotech-related inventions examined by the SIPO was around 37,300, of which 23,300 were domestic applications (62.5%) and 14,000 were foreign applications (37.5%). From 2000 on, domestic applications have exceeded foreign applications for biotech-related patent applications. In 2006, domestic applications accounted for 66% of the total applications.[110] The top ten biotechnology innovations by number of domestic patents filed are: (1) peptides that have more than 20 amino acids; (2) mutations or genetic engineering; (3) enzymes or diagnostic methods to test for microorganisms; (4) microorganisms and their combinants; (5) enzymes; (6) medical and pharmaceutical peptide substitutes; (7) chemical analyses of living organisms; (8) methods of gene modification; (9) undifferentiated human, animal, or plant cells; and (10) medical and pharmaceutical antigen or antibody substitutes. This list is very similar to the top ten technologies filed by foreign patent applicants. This indicates that China's biotechnology and

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107 The State Intellectual Property Office, Patent Examination Guidelines 2006, pt. II, ch. 10, art. 9.1.2.2

108 PRC Patent Law art. 25.

109 *See* Li *supra* note 8.

110 *Id.* at 72.

pharmaceutical sectors closely follow biotechnology advances that develop in other countries.[111]

Among all the filings in this area, applications for gene related inventions constitute more than 60%; 1321 gene patents were granted in 2008.[112] From 1996–2008, a total of 63,000 chemical drug patent applications had been examined among which 29,000 were from domestic applicants and 34,000 were from foreign applicants.[113] In terms of quality of patent applications:

> MPCs mostly focus on medicine compound (over 80 per cent) which has the highest innovative value, while Chinese applicants primarily focus on surrounding technologies such as medicine preparation craft (37.5 per cent) and medicine composition (27 per cent). The above facts indicate that foreign competitors, especially MPCs, are still technologically dominating China's chemical drugs industry.[114]

Chinese companies also filed a large number of patents applications for antibodies, for example, 5156, but it is still low compared with the 60,000 U.S. patent filings.[115] Patent applications for TCM are mostly for prescriptions rather than active ingredients and filed by individuals rather than enterprises, indicating a low level of innovation and a low rate of commercialization.[116] It is worth noting that in the last two years patent applications for pharmaceutical manufacturing has witnessed a remarkable growth in China. For example, in 2009, domestic filings for pharmaceuticals were over 10,000, and PCT filings were 317, which ranks as the second highest filing rate after patent filings for telecommunications by Chinese enterprises (see TABLE 1 above). However, the numbers are still fairly low compared to global pharmaceutical filings, for example, only 2.6% of 12,200 global pharmaceutical patent filings.[117]

In summary, patent filings in China's biotech and pharmaceutical sectors have had remarkable growth in recent years, and the areas of technology that have been filed for patent protection are closely following top technologies in the world. However, both quantity and quality of patent applications in these two fields are still relatively low compared with those in developed countries.

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111 *Id.* at 73.

112 *Id.*

113 *Id.* at 74.

114 *Id.* at 75.

115 *Id.* at 76.

116 *Id.* at 78.

117 PATENT STATISTIC REPORT, *supra* note 94, at 12.

3. Commercialization

IP commercialization in both the biotech and pharmaceutical industries in China has not been very successful. The commercialization rate of biotechnology inventions in 2002, for instance, was estimated to be 0.5%,[118] although it might be much higher now. There are major obstacles to commercialization. First, there is a lack of infrastructure for commercialization in China. The chain between universities, research institutions, biotechnology companies, pharmaceutical companies, and the national health care system is often broken, and there has been a shortage of expertise on technology transfer.[119]

Second, very few inventions have been patented. It was estimated in 2006 that only one out of thirty inventions that were published in scientific journals were filed for patents.[120]

Third, funding for commercialization has not been sufficient. Government funding is increasing but not enough:

> Even for the companies that do receive some start-up funds from the government, these funds are relatively small; for example, Chinese funding totaled $2 billion in 2007, as compared with $273 billion in 2003 by the U.S. government. Moreover, this funding does not cover all stages of commercialization, such as research done by biotechnology and pharmaceutical companies. Furthermore, funding from private investments is also very limited. While the top eight MPCs invest an annual average of twenty-three percent into R&D, the top Chinese bio-pharmaceutical companies invest less than ten percent. The lack of funding then directly affects the prospects for commercialization[121]

And "[s]ome research results stay in laboratories without ever being commercialized, while others are transferred to biotechnology companies for further R&D but are discontinued because investors are unwilling or unable to pour more money into the midstream research requiring substantial investment."[122] Private funding and VC funds are also increasing. For example, among PCT applicants, 57.9% come from individuals and 36.8% from enterprises.[123] VC funds are

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118 *Biotechnology Industry: Short of Money and Weak in Sale*, CHINAPHARM.COM (Aug. 30, 2002), www.chinapharm.com.cn/html/scfx/2002829161350.html.

119 Li, *supra* note 8, at 62.

120 Uyen Quach et al., *Biotechnology Patenting Takes off in Developing Countries*, 8 INT'L J. OF BIOTECHNOLOGY 43, 47, 53 (2006).

121 Li, *supra* note 8, at 62.

122 *Id.*

123 PATENT STATISTIC REPORT, *supra* note 94, at 3.

available, but China's capital market is plagued with irregularities and immaturity.[124]

4. Patent disputes

In China, within the pharmaceutical industry, "disputes over patent rights have been on the rise in recent years. In earlier years, these were usually disputes between Chinese companies. With the expansion of foreign drug companies into China, more disputes are found between Chinese pharmaceutical companies and MPCs."[125] For example, in 2001, twelve Chinese pharmaceutical companies filed a request with the SIPO to invalidate Pfizer's patent for Viagra in China,[126] After the SIPO issued the decision in 2004 to invalidate the patent on the ground that the patent application lacked full disclosure in its description, Pfizer sued the SIPO in a Beijing court.[127] Two years later in 2006, the court ruled in favor of Pfizer, which was appealed by the Chinese companies.[128] The Beijing High Court finally affirmed the lower court decision in 2007.[129] Another high profile dispute occurred between Eli Lilly and Ganli, a Chinese pharmaceutical company in 2005. The two companies sued each other for patent infringement of their inventions for recombinant human insulin. The Beijing High Court ruled in favor of Ganli in 2007 on the ground of Bolar exemption, that is, Ganli's act of applying "Recombinant Insulin Lispro Injection" to SFDA and obtaining the registration permit does not constitute exploration of the subject patent of Eli Lilly.[130] The third case involves a dispute between a Chinese pharmaceutical company, Wansheng, and a Japanese pharmaceutical company, Sankyo, over a patent on Sankyo's drug "Olmesartan Medoxomil" used to treat or prevent high blood pressure. Sankyo accused Wansheng of infringing its patent when producing a large quantity of Olmesartan Medoxomil during its

124 Li, *supra* note 8, at 62.

125 *Id.* at 82.

126 *Id.* at 83–84.

127 *Id.* at 84.

128 *Id.*

129 *Id.*

130 Eli Lilly Co. v. Ganli Pharm. (Beijing High Court Case (2007) Gao Min Zhong Zi No. 1844), http://blog.sina.com.cn/s/blog_6e3f5edf0100oxo3.html; *see also* Gesheng Huang, *Patent Protection of Biotechnological Inventions in China*, AMERICAN INTELLECTUAL PROPERTY LAW ASSOCIATION 2011 SPRING MEETING, CONFERENCE PAPER 11, http://www.aipla.org/committees/committee_pages/Biotechnology/Committee%20Documents/Committee%20Presentations/2011Spring%20%20Biotech%20in%20Latin%20America%20and%20Asia/Huang_Paper.pdf.

application to SFDA for drug registration.[131] The Beijing No. 2 Intermediate Court ruled for Wansheng on the same ground as in the case of Eli Lilly v. Ganli.[132] These are only three of the many cases between Chinese pharmaceutical companies and MPCs. The trend of the court rulings seems to have switched from pro-MPCs to pro-domestic companies. Whether this is a good sign for the innovation of Chinese biotech and pharmaceutical industries will be discussed later.

B. Information Technology Industry (Software and Telecommunications)

1. Software Industry

To prompt the development of the industry, in June 2000, China's State Council issued "Several Policies for Encouraging the Development of Software Industry and Integrated Circuit Industry" (Circular 18),[133] which greatly boosted the rapid growth of the two industries in China. However, after many years, China's software industry is still lagging behind the software industry of developed countries as well as some developing countries such as India. It was estimated that there were about 15,000 Chinese software enterprises by the end of 2004, and sales reached 230 billion yuan (about $35 billion U.S.) during June 2000 to December 2004.[134] In 2009, the top 100 Chinese software enterprises' sales reached 244.87 billion yuan (about $36 billion U.S.),[135] which is less than the sales of Microsoft alone ($58.4 billion).[136] On January 28, 2011, the State Council issued another notice, 2011 No. 4 Document, entitled "State Council Circular on Dissemination of Several Policies for Further Encouraging the Development of Software Industry and Integrated Circuit (IC) Industry" (Circular 4).[137] This document identifies the software industry as a "national strategic new industry," and "IP

131 Sankyo v. Wansheng (Beijing No. 2 Intermediate People's Court (2006) No. 04134, http://www.lawyerhotline.com.cn/law/show_212782.aspx.

132 *See* Li, *supra* note 8, at 87.

133 Several Policies for Further Encouraging the Development of Software and Integrated Circuit Industry (State Council [2011] Circular 4), www.gov.cn/zwgk/2011-02/09/content_1800432.htm.

134 *See infra* note 143, at slide 60.

135 *Publication of Top 100 Software Enterprises in Terms of Business Income in 2010*, CNSTOCK.COM, http://www.cnstock.com/index/gdxw/201006/573959.htm.

136 *The Future and the Trend of Software Industry*, CNSTOCK.COM, http://www.cnstock.com/index /gdxw/201006/573959.htm.

137 *Supra* note 133.

policy" as one of the seven policies provided for in this document.[138] The document stresses the importance of IP protection of software and IC, encourages the registration of software copyright, and calls for the strengthened IP protection to software and IC in the Internet environment. In addition, the document also specifically addresses the issues of commercial use of IP, such as pledge and loan, and pointed out that it is important to combat the acts of IP abuse such as excluding and constraining competition and abuse of the dominant position.[139]

Computer programs, per se, are not patentable under Chinese Patent Law Article 25.[140] In order to get a patent grant, a computer program must constitute technical features or solutions that can solve technical problems and achieve technical effects.[141] The following software-related inventions have been considered patentable: the program used in industrial process control to improve computer internal process, in measurement, control of measurement, or test processes, in external data processing, and in coding and imputing Chinese characters.[142] Pure software, software recorded on CD-ROM, and simple pieced-together software stored in the computer memory with processing equipment are not patentable due to the lack of technical solutions.[143] Compared with Europe and the United States, Chinese patentability criteria for computer software are more restrictive as they require technicality in three aspects: feature, means, and effects, while the EU only requires "technical contributions,"[144] and the U.S. grants patents to any computer program that is "useful, concrete and [produce] tangible result[s]."[145] The restrictiveness of the patentability criteria has direct impact on patenting activity. For

138 *Id.* The other six policies are: (1) tax policy; (2) investment policy; (3) R&D policy; (4) import and export policy; (5) talent policy; (6) market policy.

139 *Id.*

140 PRC Patent Law art. 25.

141 PATENT STATISTIC REPORT, *supra* note 94, at ch. 9, § 2.

142 *See supra* note 133.

143 Lulin Gao, PowerPoint presentation of *Software Patents in the World and China's Policy Options* 45 (Sept. 1–5, 2008) (on file with author).

144 Vicom/Computer-related Inventions [1987] 2 EPOR 74.

145 2106 Patent Subject Matter Eligibility [R-6]—2100 Patentability, IV-C-2(2), http://www.uspto.gov/web/offices/pac/mpep/documents/2100_2106.htm; *also see In re Alappat*, 33 F.3d 1526 (1994); *State Street Bank & Trust Co. v. Signature Fin. Grp., Inc.* 149 F.3d 1368 (1998) "Although CAFC decided in *In re Bilski* 545 F.3d 943 (2008) that the test of 'useful, concrete, tangible results' should no longer be relied upon, instead, the test of 'machine-or-transformation' should be applied to determine the patentability of a software, the Supreme Court rejected this ruling, and ruled that 'machine-or-transformation' test should not be a sole test for patentability of software."

example, before 1993, China's Patent Examination Guidelines (1986) required that computer programs be designed to cause changes (e.g., improvement or controlling function) of computer hardware to be patentable.[146] Under this requirement, very little computer software was patentable. Accordingly, the number of annual patent applications for software before 1993 was under 100, accounting for only 0.5% of the total annual patent applications in China.[147] In 1993, the Guidelines were revised to abandon the "hardware change" requirement, and to allow a computer program to be patented as long as it possesses some technical features and can be used as a technical means to produce some technical effects.[148] As a result, annual software patent applications reached 1000 in 2000, accounting for 2.19% of national filings.[149] In the period of 2000–2005, the growth rate of annual software patent filings was maintained at about 53.7%.[150]

However, compared with other industries, patent applications for computer software among Chinese software companies are still generally low. The diagram above shows that both PCT and domestic filings for software by Chinese companies are at the lower end, accounting for 6.7% and 5.7% respectively. This has not excluded the filings for information transmission and computer service technologies. According to statistics, from 1990 to 2008, a total of 59,755 software patents were granted in China, of which 22,297 were granted to the top ten software companies.[151] Among those companies there was only one Chinese company, ZTE, which owns 868 software patents.[152] Out of the forty-six companies that owned over 200 patents, only five Chinese companies held 5.5% of all granted software patents, while American and Japanese companies together held 36.1% of Chinese software patents.[153] This indicates that the majority of Chinese software patents are in the hands of multinational corporations. In addition, none of the five Chinese companies mentioned above are pure software companies; rather, their main

146 Liu Shan & Yu Xiang, *An Empirical Studies on the Patenting in Chinese Software Industry*, SCIENCE & TECHNOLOGY PROGRESS AND POLICY No. 22 (2009).

147 *Id.*

148 *Id.*

149 *Id.*

150 *Id.*

151 *Id.*

152 *Id.*

153 *Id.* The five Chinese companies are: ZTE, Huawei, Zhongxing, Yingyeda, Haichuan; *id.*

businesses are electronic technology, telecommunications, and mechanical manufacturing.

Whether the low rate of patent filings for computer software is the cause of the low level of innovation in China's software industry is not very clear. From various discussions and public speeches, it seems that IP is not a major factor contributing to the low level of innovation in this industry.[154] The frequently mentioned factors include the small scale of industry, lack of funding from VC, and lack of talents.[155]

2. Telecommunications Industry

China is now being viewed as "a telecommunications manufacturing and research powerhouse."[156] Due to its large population, China owns the largest fixed-line and mobile network in the world. As of June 2010, China has 306 million fixed-line subscribers and 796 million mobile customers. Technologies that have been used to provide services including ADSL, wireless LAN, IP (Internet Protocol) telephone, SMS, MMS, and ring tone downloading.

The Chinese telecom industry has been dominated by three state-run businesses: China Telecom, China Unicom, and China Mobile. Two other telecom companies, Huawei Technologies Co., Ltd. and ZTE Corporation, rose very quickly as telecom equipment manufacturers. They together occupied 66% of Chinese 3G wireless equipment market (thirty percent and thirty-six percent respectively). Huawei is the world's second largest telecom equipment provider, the largest mobile broadband provider with 55% market share, first in the Mobile Softswitch market with 40.6% market share, and first in the IMS&NGN market by revenue with 27% market share.[157] Hauwei's sales revenue exceeded $21.8 billion USD in 2009, and net profit reached $2.7 billion USD in 2009.[158] ZTE is the second-largest

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154 *See, e.g.*, *The Analysis of the Development and Surviving Condition of China's Software Industry*, http://www.iteye.com/topic/59258 (last visited Sept. 14, 2011); Research Report of the Development Strategies of China's Software Industry, http://www.chinairn.com/doc/40140/256621.html.

155 *Id.*

156 Richard McCormack, *China Gaining Control of Global Telecom Industry*, SECOND LINE OF DEFENSE, http://www.sldinfo.com/china-gaining-control-of-global-telecom-industry/ (last visited Sept. 2, 2011).

157 *Corporate Media Kit—Fact Sheet & Milestones*, http://www.huawei.com/en/about-huawei/newsroom/resources/corporate_media_kit/index.

158 *Huawei* Technologies Limited, 2009 Annual Report, Letter from the CEO 2 (2009), *available at* http://www.huawei.com/en/ucmf/groups/public/documents/webasset/hw_092117.pdf.

Chinese telecom equipment maker, the world's fifth-largest mobile phone manufacturer, and the world's third-largest vendor of GSM telecom equipment, with sales accounting for about 20% of all GSM gear sold in the world in 2009.[159]

The two companies also rank among the top ten patent applicants under the PCT system. Huawei ranked first, second, and fourth in 2008, 2009, and 2010 respectively, and ZTE jumped from twenty-third in 2009 to second in 2010.[160] Specifically for Huawei, the company adopts a "customer-centric" innovation strategy and focuses on filing patents, adopting technology standards, and seeking cross-licensing deals.[161] As of December 2010, Huawei filed a total of 49,040 patents of which 17,765 had been granted. Among its filings, 800 to 900 were filed in the United States, about 600 in Europe, and 200 to 300 in Japan,[162] indicating that its primary customers are overseas. Huawei also adopts a vigorous patent review system under which its patent review board would reject, based on the scores of different criteria, about 50% of the patent applications proposed by its employees.[163] Huawei also holds 7% of the world's Universal Mobile Telecommunications System (UMTS) essential patents, and participated in 123 international standard groups including ITU, 3GPP, 3GPP2, OMA, ETSI and IETF.[164] Huawei's strength in patent filing comes form its R&D division, where 46% of Hauwei's employees are engaging in R&D and 10% of its annual revenues are invested in R&D (e.g., $2.5 billion invested in R&D in 2010).[165] The company operates twenty R&D centers, of which thirteen are located in other countries including Germany, France, Italy, Russia, India, the United States, and Canada.[166]

Huawei is also fairly active in seeking licensing opportunities. In 2010, the company paid Western companies $222 million in licensing

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159 *See* Interview-China's ZTE aims for fifth of Global GSM Gear Market Reuters (Nov. 18, 2009), *available at* http://www.reuters.com/article/2009/11/18/idUSHKG24779620091118.

160 *China's International Patent Filings on 56.2% Jump last Year WIPO*, *available at* http://news.xinhuanet.com/english2010/china/2011-02/10/c_13724928.htm.

161 Presentation by Huawei Legal Group at Huawei (July 27, 2011) (notes on file with author).

162 *Id.*

163 *Id.*

164 *Id.*

165 *Id.*

166 *Id.*

fees and signed cross-licensing agreements with all major IPR holders in the industry.

ZTE, for its part, equally attaches a great importance to patenting. As mentioned above, the company took second place in the list of PCT patent publications in 2010 with 1863 patent filings, jumping from twenty-third in 2009. Forty-five percent of the company's patents in 2009 were filed for 3G and 4G technologies, as well as in the terminal, access, bearer network, and chipset technology fields. Out of 25,000 patents filed by ZTE, over ninety percent are invention patents, including over 1,700 LTE/SAE patents.[167] In addition, the company is a member of seventy standard organizations and holds important positions within those organizations.[168]

As the telecom business grows and the number of patents increases, lawsuits between the two Chinese telecom rivals and the telecom companies of other countries have become more frequent. In early April 2011, Ericsson sued ZTE in the U.K., Italy, and Germany for infringement of patents for GSM and WCDMA after trying to reach a patent licensing agreement with ZTE, under which ZTE would have to pay royalties to the Swedish company.[169] In retaliation, ZTE also filed a patent infringement lawsuit against Ericsson (China) Communications Co. in Beijing, alleging that Ericsson products sold in China infringed ZTE's patents on core networks, global system for mobile communications, and 4G mobile technology.[170] ZTE also planned to invalidate Ericsson's three patents in China covering 2G and 3G mobile technologies on the ground that they do not meet the criterion of inventive step.[171] Then, on April 28, 2011, Huawei filed lawsuits against ZTE in Germany, France, and Hungary for allegedly infringing Huawei's patents relating to data cards and 4G wireless LTE technologies and for illegally using Huawei's trademark on its data card products, and was awarded an injunction.[172] One day later, ZTE counter-sued Huawei for patent infringement over its fourth-

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167 *Id.*

168 *Id.*

169 David Stanway, *Ericsson to Sue China'c ZTE Over Patent Breaches—Report*, REUTERS (Apr. 1, 2011), http://www.reuters.com/article/2011/04/02/china-ericsson-zte-idUSL3E7F201F20110402.

170 Owen Fletcher, *ZTE sues Ericsson in China, Escalating Clash*, WALL ST. J. (Apr. 12, 2011), http://online.wsj.com/article/SB10001424052748704662604576256440263520456.html.

171 *Id.*

172 Michael House, *Huawei Awarded Injunction Against ZTE*, MOBILE NEWS, (May 12, 2011), http://www.mobilenewscwp.co.uk/2011/05/huawei-awarded-injunction-against-zte.

generation Long-Term Evolution, or LTE, cellular wireless technologies in China.[173] These lawsuits demonstrate that China's telecom companies are not only competing with global rivals in filing patents, they are also competing with each other by using patent lawsuits both defensively and offensively.

C. Environment-Related Industries (Automobile and Green-Technologies)

1. Automobile Industry

In September 2011, Xinhua reported that the number of automobiles in China had reached 100 million.[174] China has become the world's largest automotive market since 2009. Of the automobiles produced, 44.3% are local brands (BYD, Lifan, Chang'an, Geely, Chery, Hafei, Jianghuai, Great Wall, Roewe), with the rest being produced by joint ventures with foreign car manufacturers.[175] However, the innovation level of the industry is considerably low. According to Xu Ping, Party Secretary of Chang'an Automobile Co. Ltd., there are about four R&D models in Chinese auto industry: simple imitation, borrowing multinational platforms, mimicking the appearance of other foreign brands, and independent innovation.[176] Most of the Chinese auto companies are adopting the first three models. For example, the designer of Chery's QQ was accused of being an imitation of Chevrolet's "Spark."[177] Honda has alleged that its design was copied by Shijiazhuang ShuangHuan Automobile and Hebei Xinkai Automobile,[178] and Italian automaker Fiat has sued

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173 *Huawei, ZTE patent war against the outcome of the origin of the European Union has recently released three*, EZINEMARK.COM (May 6, 2011), http://business.ezinemark.com/huawei-zte-patent-war-against-the-outcome-or-the-origin-of-the-european-union-has-recently-released-three-17e466132be.html.

174 Lei Xing, *Number of Cars in China Hits 100 Million*, CHINA AUTO. REV. (Sept. 16, 2011), http://www.chinaautoreview.com/pub/CARArticle.aspx?ID=6597.

175 *Automotive Industry in the People's Republic of China*, WIKIPEDIA, http://en.wikipedia.org/wiki/Automotive_industry_in_the_People's_Republic_of_China.

176 *Xu Ping: China's Auto Industry Competition is the Essence of Innovation*, FREE PAPER WORLD NEWS (Sept. 7, 2011), http://www.f-paper.com/?i884316-Photo:-Xu-Ping:-Chinas-auto-industry-competition-is-the-essence-of-innovation.

177 Gong Zhengzheng, *GM charges Chevy for Alleged Mini Car Piracy*, CHINADAILY, (Dec. 18, 2004), http://www.chinadaily.com.cn/english/doc/2004-12/18/content_401235.htm.

178 *Honda Sues China Car Company for Patent Infringement*, EPOCHTIMES, (Apr. 7, 2004), http://en.epochtimes.com/news/4-4-7/20790.html.

Great Wall Motors for infringing its design for the Peri.[179] These cases indicate the seriousness of the imitation problem among Chinese companies and the importance of filing patents in China to prevent imitation.

Chinese auto companies' trouble with infringement lawsuits derives largely from their lack of IPRs. Among the top ten patent filers shown in Table 1, transportation manufacturing ranks seventh, accounting for only 4.5% of PCT filings and 4.4% of domestic filings. Patents for automobiles may constitute an even smaller percentage among the transportation manufacturing industry. Chinese automobile companies typically hold very few patents. For example, Chery had a total of 196 patents by 2005 (five invention patents), compared to Toyota's 3145 Chinese patents by 2005 (2473 invention patents).[180] Before 2005, none of the five Chinese automobile companies (Dongfeng, Chery, Chang'an, FAW and Geely), had applied for more than one hundred invention and utility model patents. Most of the companies applied for less than forty annually, with the exception of Dongfeng who applied for one hundred in 2003, and Chang'an who applied for sixty in 2004.[181] In comparison, annual applications for invention and utility patents filed in China by some foreign original equipment manufacturers (OEMs), such as, Honda, Toyota, Nissan, and GM, during the same period exceeded one hundred, with Honda filing about 400 each year before 2003, close to 500 in 2004, and more than 500 in 2005.[182] Interestingly, Chinese automobile companies filed more design patents than invention and utility model patents. For example, Chang'an filed more than 300 design patents in 2005.[183] Compared to invention and utility patents, foreign OEMs filed fewer design patents in China. For example, Honda filed fewer than 100 design patents in 2005, and GM filed none from 2001 to 2005.[184] This may be one of the factors that contributed to the disputes between Chinese and foreign auto

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179 Bertel Schmitt, *The Middle Kingdom Strikes Back: Great Wall Sues Fiat For Espionage*, THETRUTHABOUTCARS.COM (Oct. 27, 2009), http://www.thetruthaboutcars.com/2009/10/the-middle-kingdom-strikes-back-great-wall-sues-fiat-for-espionage.

180 Wang Lianfeng and Wang Chunhua, *Intellectual Property Protection and Strategy in China'c Automobile Industry*, in Zhang Naigen and Chen Naiwei (eds.), TECHNOLOGY TRANSFER, FOLLOW-UP R&D, AND DISPUTE SETTLEMENT (2009), at 51.

181 Greg Brown, *Auto Industry IP Protection in China* (June 11, 2007), http://www.ipoef.org/AM/Template.cfm?Section=Programs&Template=/CM/ContentDisplay.cfm&ContentID=15159.

182 *Id.*

183 *Id.*

184 *Id.*

companies over design patents. For example, in *Chevrolet "Spark" v. Chery QQ* case, GM did not even file a patent for its design in China.[185]

Compared with foreign auto companies, Chinese auto companies filed even fewer patents in other countries. Prior to 2007, there was only one application by a Chinese OEM filed in a European patent office. In terms of quality, multinational auto companies pay more attention to new energy vehicle technology and electronic control technology while Chinese companies focus on engine, body, and body ancillary systems technology.[186]

Interestingly, a study by Ping Zhang and Huaiwen He found that China First Automobile Works Group Corporation (FAW) filed the highest number of patent applications, seventeen, in 2005, but suffered a profit loss in the same year, and the company blamed the heavy investment in R&D for the loss.[187] The FAW case indicates that Chinese auto companies face great difficulties in engaging R&D, let alone IP commercialization. The low rate of patenting may also be attributable to the fact that China is a late-comer to the auto industry, within which most basic technologies have already been patented. In addition, the Chinese auto industry also faces the difficulty of in getting new technology transferred from the multinational corporations as many technology transfer contracts contain prohibiting clauses. Without enough IPRs and technology transfers, Chinese auto companies are forced to imitate, which leads to greater risk of IP infringement. Currently, the R&D and business models adopted by the Chinese auto companies primarily include the following: (1) technology transfer; (2) collaboration in R&D; (3) controlling share or acquisition; and (4) commissioned R&D. Through these models, Chinese auto companies may hope to get more IPRs. For example, Geely acquired Volvo and all of its IPRs; and SAIC acquired South Korea's Ssang Yong, with its controlled SUV

185 *Id.*, slide No. 6.

186 Yueli Tang & Shengwei Hu, *Comparison of Micro Auto Patents Between China an Foreign Company Based on Patent Map*, *in* BUS. MGMT. AND ELECTRONIC INFO. (BMEI), 2011 INT'L CONF., 395, *available at* http://ieeexplore.ieee.org/xpl/freeabs_all.jsp ?arnumber=5914503 (last visited Sept. 14, 2011).

187 Huaiwen He & Ping Zhang, IMPACT OF THE INTELLECTUAL PROPERTY SYSTEM ON ECONOMIC GROWTH: FACT-FINDING SURVEYS AND ANALYSIS IN THE ASIAN REGION, COUNTRY REPORT—CHINA 10 (WIPO-JPO-UNU Joint Research Project, 2007), *available at* http://www.wipo.int/about-ip/en/studies/pdf/wipo_unu_07_china.pdf.

and C level platform and auto engine technology, and also acquired Rover's 75 and 25 core IPRs.[188]

2. GreenTech Industry.

According to "The China Greentech Report 2011" produced by China Greentech Initiative, China has emerged as a global greentech leader.[189] By the end of 2010, China had invested 354 billion yaun ($54.4 billion); installed 44.7 GW of wind power; built 8,358 kilometers of high speed rail; and China's greentech market covered wind, solar power, emissions control, and wastewater treatment.[190] There are about six greentech sectors: cleaner conventional energy, renewable energy, electric power infrastructure, green building, cleaner transportation, and clean water.[191] Each sector has its strengths and weaknesses in R&D. For example, China ranks first in manufacture and consumption of solar water heaters, but it is still focusing on the technology of producing low temperature water and solar photovoltaic (PV) products, which are mostly exported. The technology for solar power generation systems, large-scale solar power collection and storage, and light-heat conversion techniques is still in the preliminary stages. China lacks the technology for producing high quality solar cells, so 90% of the materials for solar cells have to be imported, while most advanced countries refuse to transfer the technology and so 91.22% of power is still produced by traditional resources such as coal. By 2010, the installed capacity for wind power should have reached 20.00 million kw, but China is still backwards technologically on wind turbines and large scale wind power integration.[192]

Obtaining patents on greentech is a challenge for the Chinese greentech sector, as in auto industry, because greentech involves many conventional technologies which have already been patented by developed countries and new technologies are held mostly by U.S.

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188 Chris V. Nicholson, *Chinese Carmaker Geely Completes Acquisition of Volvo From Ford*, N.Y. TIMES, Aug. 2, 2010, http://www.nytimes.com/2010/08/03/business/global/03volvo.html. Also see *Implementing the Scientific Development Philosophy and Fulfill Corporate Social Responsibilities*, SAIC MOTOR, http://www.saicmotor.com/english/xwzx/xwk/3605.shtml.

189 CHINA GREENTECH INITIATIVE, THE CHINA GREENTECH REPORT 2011, *available at* http://www.pwccn.com/webmedia/doc/634394109978005634_cn_greentech_report_apr2011.pdf (last visited Sept. 15, 2011).

190 *Id.* at 11.

191 *Id.*

192 *Id.*

companies that refuse to transfer to Chinese companies because the U.S. government and industries wish to keep green jobs at home[193]. Therefore, unlike other industries, the number of patent applications for greentech filed in China by foreigners is fairly small. The following statistics show a compilation of patent applications for greentech filed with the SIPO in the period of 2005–2009:[194]

- Wind technology (e.g., wind turbine): total 1622 applications, among which 1435 are from Chinese applicants and 87 from foreign applicants, and 51.2% for utility models.
- Hydrogen technology (e.g., fuel cells): total of 739 applications, among which 657 are from Chinese applicants, 82 from foreign applicants, and 254 for utility models (all from Chinese applicants).
- Biomass energy technology (e.g., biofuel): total of 791 applications, among which 292 are for invention patents and 498 are for utility models.
- Ocean & water energy (e.g., hydraulic turbine): total of 451 applications, among which foreign applicants account for 24%.
- Natural gas: total of 772 applications, among which 50.09% are for invention patents and 20.86% are from foreign applicants.

These figures suggest three things: (1) the total number of patent applications in the greentech field is generally low; (2) foreign companies and individuals are reluctant to file greentech patents in China; and (3) too many applications for utility models indicates that the patent applications filed by the Chinese heavily concentrate in low level technologies. We can, therefore, conclude that the innovation capability of the Chinese greentech industry is still very weak, and can be worsened by the reluctance of foreign greentech superpowers, particularly the United States, which holds 50 percent of greentech patents, to transfer their technologies to China. These superpowers

193 *See* Letter from Alliance for Clean Technology Innovation to Secretary Hillary Clinton and Special Envoy for Climate Change Todd Stern Regarding IPR and Technology Discussions at Cancun Climate Change Talks, December 7, 2010, *available at* http://www.bio.org/sites/default/files/20101207.pdf; *see also* John Lorinc, *Climate Change and Intellectual Property*, N.Y. TIMES GREEN BLOG, Nov. 28, 2011, http://green.blogs.nytimes.com/2009/06/11/climate-change-and-intellectual-property/; GLOBAL INTELLECTUAL PROPERTY CENTER, Report: Efforts to Weaken IP Would Cost U.S. Millions in Green Jobs, *available at* http://www.theglobalipcenter.com/sites/default/files/GIPC_-_Green_Jobs_Leave_Behind.pdf.

194 FUDAN UNIVERSITY INTELLECTUAL PROPERTY RESEARCH CENTER, Technology Transfer Issues in Past-Kyoto Protocol Era, High Level Forum Materials 4, 9, 15, 17, 18 (2009) (on file with author).

may one day speed up their patent filings in China, but before they do that China can only rely on itself to develop its greentech.

III
IP AND INNOVATION IN CHINESE HIGH-TECH INDUSTRIES: REFLECTIONS

Part I of this paper introduced the prevailing views on the relationship between IP and innovation which are very diverse, some contradictory and some industry-specific. Adopting the industry-specific approach, Part II of the paper empirically investigated six of China's high-tech industries, their industry and market scale, R&D capability and models, and patenting filing and litigation status. These two parts serve to provide some useful information for readers to compare and to reflect on the role of IPRs in different countries and different industrial sectors. What follows are some immediate reflections of my own on the above two parts.

First, IPRs may not play any role in innovation in some developing countries and the least developed countries (LDCs) which are extremely poor and do not have any innovation capacity, but they do play some role in promoting innovation in developing countries which are relatively well off and have a high tech capacity. The role of patents in China is evidenced by the parallel growth of patents and the national economy. China is the largest developing country with the per capita gross national income ranking 127th in the world, but by the second quarter of 2010 it has became the second largest economy with a GDP of $1.337 trillion.[195] In addition, China is also a country with a relatively high technological capacity which makes patents relevant to innovation. According to the CIPR's report, technological capacity is determined based on the extent of patenting activity in the United States and through the Patent Cooperation Treaty (PCT).[196] In 2010, China filed 6552 patent applications with the USPTO.[197] In 2010, China's PCT applications reached 12,339, up from 7900 applications registered in the previous year, ranking China

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195 *China Overtakes Japan as World's Second Biggest Economy*, BLOOMBERG NEWS, Aug. 16, 2010, http://www.bloomberg.com/news/2010-08-16/china-economy-passes-japan-s-in-second-quarter-capping-three-decade-rise.html.

196 COMMISSION ON INTELL. PROP. RTS., *supra* note 41, at 13.

197 STATE INTELLECTUAL PROP. OFFICE OF CHINA MGMT. & DEV. BUREAU, *Steady Increase in our Foreign Invention Patent Applications in 2010*, PATENT STATISTIC REPORT, No. 4, Mar. 15, 2011, *available at* www.sipo.gov.cn/ghfzs/zltjjb/2011042259920483079 9.pdf.

fourth among all other countries for PCT filing.[198] These figures demonstrate that China is a developing country with a relatively high technological capacity in which patents respond to innovative activities more positively than in technologically weak developing countries.[199]

Secondly, IPRs may not be crucial for generating inventions, but they are indispensable for commercialization. Innovation process involves many factors and stages including invention and commercialization, and whether a country is innovative is assessed by how many of its inventions can be commercialized into useful products. Although many inventions start with inventors' pure intellectual curiosities and public funding support without much IPR incentive, IPRs (particularly patents) are extremely important in securing financial investment and technology licensing in commercialization process. The United States' success in commercialization of its vast amount of inventions can be attributed to its pro-innovation patent system and its leading position in patenting. On the other hand, the weakness in the commercialization of inventions in most Chinese industries indicates that the role of IPRs needs to be strengthened. Despite the impressive number of patent applications, China remains a largely imitation-oriented country. This is due partly to bad IP management and the low rate of IP commercialization. For example, it was estimated that the commercialization of inventions in Chinese universities is about ten percent, which is fairly low compared with thirty percent commercialization rate of universities in industrialized countries.[200] Without commercialization, many inventions, even patented, will remain in laboratories. The Chinese government has recently recognized the adverse impact of low commercialization on the development of China's knowledge-based economy and the process of transforming it into an innovation-oriented country, and adopted national policy and laws addressing the importance of commercializing technologies. For example, the "Outlines of the

198 China filed 12,339 PCT applications in 2010. The top three countries are the Unites States (44,855), Japan (32,156), and Germany (17,171). *See China's International Patent Fillings on 56.2-pct Jump last Year: WIPO*, PEOPLE'S DAILY ONLINE, http://english.peopledaily.com.cn/90001/90776/90881/7282696.html.

199 CIPR, INTEGRATING INTELLECTUAL PROPERTY RIGHTS AND DEVELOPMENT POLICY 4 (2004).

200 Chen Meizhang, *Thoughts on Industrialization of University Patent Technologies*, *in* LEGAL THEORIES AND PRACTICES IN TECHNOLOGY TRANSFER 163 (Zhang Naigen & Chen Naiwei, eds., 2006).

National Intellectual Property Strategy" has made "utilization" of IPRs an important strategy.[201] The "Law on Science and Technology Progress" was amended in 2008 to add an objective of "promoting the transformation of scientific and technological advances into practical productive forces."[202] Furthermore, the government has formed some national programs to promote the commercialization of R&D results by linking upstream, middle-stream, and down-stream research, as well as tightening the alliances between education, research, application, and production. For example, various Ministries of the central government, together with local governments, have launched the programs including "1,000 new-energy vehicles in 10 cities," "100,000 energy-saving LED street lamps in 10 cities," "golden sun," and "next generation broadcasting network," among others. These programs are useful in connecting university research projects with the practical needs of emerging strategic industries.[203] Whether these efforts to promote commercialization can turn China's large stock of patented technologies into commercial products remains to be seen, but China is certainly moving in the right direction. Based on the United States' experience, to be successful in IP commercialization, a pro-innovation patent system has to be in place, which includes broad patentable subject matters, an inventor-friendly patent prosecution system, and a pro-patentee litigation system. This pro-innovation patent system needs to be supported by comprehensive national legislation on IP commercialization and innovation.

Thirdly, IPRs may not play any role in one particular industry, but they may play a significant role in another industry; in other words, the role of IPR varies in different industries and technological sectors. This has particular implications for China. The success of some of China's industries and technological sectors, such as biotech and telecom, is attributable to a high rate of patenting and good IP strategy, while the backwardness of others, like the pharmaceutical and automotive industries, may be caused by low patent rates or poor

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201 OUTLINE OF THE NATIONAL INTELLECTUAL PROPERTY STRATEGY, Article 2(6) (issued by the State Council of The People's Republic of China on June 5, 2008) (Yangtze Yan ed., June 21, 2008), *available at* http://www.gov.cn/english/2008-06/21/content_1023471.htm.

202 PRC on Progress of Science and Technology, CHINAORG.CN (Order of the President of the People's Republic of China No. 82, Dec. 29, 2007, effective July 1, 2008), http://www.china.org.cn/china/LegislationsForm2001-2010/2011-02/11/content_21899295.htm.

203 *New Mechanism Aids Commercialization of Research*, PEOPLE'S DAILY ONLINE (Apr. 7, 2011), http://www.chinaipmagazine.com/en/news-show.asp?id=2853.

patent strategy. IP (or patents) may not be an important factor in innovations in some of the Chinese industries, like software, but some sectors may urgently need more indigenous IPRs to boost R&D because foreign IPR holders refuse to transfer their technologies, as was the case in the greentech industry. The barriers for tech transfer of core technologies are still high and, therefore, the role of patents to promote self-innovation in China is crucial.

Lastly, IPRs may be overprotected in many developed countries, but they may be still under-protected in China. Unlike the U.S. IP system which has over 200 years of history and, in some instances, has been abused by right-holders to prevent competition and access to technologies, China's IP system, on the other hand, is less than thirty years old and needs to be matured. The potential of the IP system for promoting innovation has not been fully reached. China should strengthen rather than weaken its IP system in order to promote innovation.

CONCLUSION

As a developing country with a high technological capacity, China is on its way to transforming itself from a world's manufacturing center to a knowledge-based society and from an imitation-oriented country to an innovation-oriented country. China is destined to become not only a "greentech leader" or an "automobile powerhouse," but also a top IPR holder and a Champaign for IPR protection, because technology and IPRs should go hand-in-hand.

Currently, the numbers of IPRs that Chinese inventors and enterprises hold are insufficient and disproportionate to the scale of the industry and market, even when compared with R&D capability in some sectors. The leading position of a few Chinese companies in PCT filings for one industry sector does not represent the true state of development of other industrial sectors. China has a long way to go to become a real innovative country, and IP still has its unique role to play in helping China to become one.