# Technology Transfer Snapshots from Middle-Income Countries: Creating Socio-Economic Benefits through Innovation

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## ABSTRACT
This chapter examines the outcomes of technology transfer policies adopted in the past 20 years by five middle-income countries: Brazil, India, Ireland, Israel, and Jordan. The outcomes in those countries suggest that nations whose governments enable the assimilation of new technologies grow faster, create more jobs, and reduce poverty levels. The outcomes suggest also that a mixture of government and market strengths are needed to efficiently use technology transfer. Without this balance, technology transfer will have limited effects.

## 1. INTRODUCTION
The founders of the United States understood the importance of innovation and took pains to promote and protect it in the U.S. Constitution:

> *The Congress shall have power to lay and collect taxes, duties, imposts and excises, to pay the debts and provide for the common defense and general welfare of the United States; but all duties, imposts and excises shall be uniform throughout the United States; … 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.* (U.S. Const. article I, § 8, cl. 8)

The same principles embodied in this Constitution are used around the world today to encourage research and development. For example, inventors and developers can apply for patent rights that give them exclusive use of their own innovations for a limited period of time. Patent rights are essentially "negative" rights: that is, they allow one party to exclude others from gaining benefit from an inventor's work, but, of course, they cannot ensure that the invention will be profitable. In return for the patent right, the inventor discloses information in the patent that would enable a person who is "skilled in the art" (that is, knowledgeable in the field of the invention) to understand and replicate the invention for him- or herself. Patents thus seek to serve both the inventor's and the community's interests.

We can see this dual effect in the case of a well-known American. George Washington was a mill owner and operator eager to improve his mill's productivity. He was interested in new agricultural technologies, particularly in the Evans Mill System, patented by the prolific inventor Oliver Evans (U.S. Patent No. 3), and now recognized as the first mass production process. As president, Washington reviewed and signed all of the patents issued in 1790; and as the owner of the Mount Vernon Gristmill, Washington was one of the first to license the new technology. This automated mill produced high-quality flour using two men instead of six; the mill operated continuously and turned out greater quantities of flour than the traditional process in a fraction of the time. In addition to Washington, within two

Finston SK. 2007. Technology Transfer Snapshots from Middle-Income Countries: Creating Socio-Economic Benefits through Innovation. In *Intellectual Property Management in Health and Agricultural Innovation: A Handbook of Best Practices* (eds. A Krattiger, RT Mahoney, L Nelsen, et al.). MIHR: Oxford, U.K., and PIPRA: Davis, U.S.A. Available online at www.ipHandbook.org.

years, over a hundred other U.S. mills were using the new Evans technology. Evans' invention changed U.S. mills forever and boosted U.S. agricultural exports to Europe. It benefited not just Evans but the entire country, including George Washington.[1]

Another example, predating Bayh-Dole, involving the contrasting paths of penicillin and streptomycin underscores the importance of incentives to ensure commercialization of science. Penicillin was first discovered in 1928, and is often cited as a laudable case where the innovator, Dr. Louis Pasteur, did not seek a patent or licensing for the drug. As a result, however, there was no commercial development of penicillin, for more than a decade, until World War II necessitated scale-up and mass manufacture of the drug.[2] In contrast, streptomycin, developed by Dr. Salman Waksman at Rutgers University in the 1930s, was on a faster track, enabled by an early exclusive licensing agreement with Merck.[3]

Then as now, a climate that encourages the adoption of new technologies will also encourage increased rates of job creation, lower poverty levels, and create greater opportunities for economic growth. We live in an unprecedented era, however, when the investment assets of companies are increasingly intangible, and particularly suited to forms of IP protection.[4] Microsoft® founder Bill Gates concludes that the nature of the global economy increases the need for incentives to innovation given "*the economic competition between nations going forward, particularly with regard to the rapid innovation and development in emerging countries … We need incentive systems that drive that innovation in an appropriate manner, because we can no longer compete exclusively on the basis of cost of labor.*"[5] This chapter looks at how technology transfer policies have affected countries from three different regions (the Middle East, Asia, and Europe) in the past 20 years.

## 2. WHAT IS TECHNOLOGY TRANSFER?

T*echnology transfer* is the process of developing practical applications from the results of scientific research. Defined more broadly, technology transfer is anything that increases the capacity of people to benefit economically and/or socially from innovation.

Technology transfer is a complicated process, and the journey from exploratory research to successful product can be a long one. R&D falls into three categories or phases:

- The primary objective of *basic research* is the advancement of knowledge for its own sake. This type of research is exploratory or investigative and is often driven by the researcher's curiosity, interest, and hunches.
- The primary objective of *applied research* is to answer specific questions that have practical ramifications. These questions may or may not arise out of basic research. Applied research can be exploratory, but is usually more focused.
- In *commercial development*, ideas arising from basic and/or applied research are used to create a product intended for commercial sale.

An example of an R&D process that includes all three phases is the discovery and development of pharmacogenetic drugs: decoding the human genome (basic research) led to the identification and isolation of particular enzymes (applied research), which in turn led to the development and testing of drugs (commercial development). This example suggests that governments have a significant role to play in identifying which areas of innovative research can and should be promoted (the initial research on the human genome was a public effort). Governments also have a role in moving inventions from the theoretical level to the applied level (government-funded research drives a good deal of this movement) and in providing incentives to encourage the development of new products and processes arising out of applied research (for example, forms of intellectual property). But as research moves further from basic research toward product development, the government's role in directing this process diminishes. For the most part, the market distributes investment resources much more efficiently than the government.

## 3. WHAT FACTORS PROMOTE TECHNOLOGY TRANSFER?

The core elements of a robust technology transfer system are:

1. *a durable government commitment to science education, research, and related infrastructure.* Governments create an enabling environment for science and technology by investing in education and training (both at home and abroad, at secondary and university levels), funding basic and early applied research, and improving technology-related physical infrastructure.
2. *broad rule-of-law protections, including strong IP protections.* Rule-of-law protections give individuals the ability to enter into enforceable agreements or contracts with others; they promise predictable and timely judicial remedies in case these agreements or contracts are breached.
3. *reliance on market forces as the engine for technology transfer.* Market-oriented policies encourage risk taking and increased private sector investment.

These three pillars of technology transfer are like the three legs of a stool: all are necessary, and none of them is sufficient by itself. However, it can be difficult to provide all three simultaneously. In the mid-20th century, the U.S. government thought it strongly supported science, rule-of-law protections, and market incentives, but it did not grant private rights to publicly funded inventions. The effect of this was to greatly weaken market incentives for investing in new technologies. Such rights only became part of the U.S. technology transfer regime with the passage of the Bayh-Dole Act of 1980.[6] Once government-funded scientists were allowed to engage with those who had the skills needed to bring products to market, an explosion of innovation ensued, bringing remarkable new products in health, agriculture, and other fields.

## 4. TECHNOLOGY TRANSFER PROFILES

The power of technology transfer is available to people everywhere, and it is a power that can facilitate not just a nation's research abilities but its overall economy. Drawing on his experience in Bangladesh, David Sack, observed that:

> *[W]ell-qualified local scientists generally prefer to remain in their home country if they can find meaningful employment in institutions where they can be productive. Well-functioning institutions contribute to "brain-gain," thus increasing the scientific and economic resources of a country as a whole.*[7]

No matter what stage of development a country is in, its government can train scientists and encourage them to remain at home by promoting a sensible, well-functioning technology transfer system. The remainder of this chapter provides brief profiles of five middle-income countries whose governments, over the past two decades, have supported science and education, created effective IP protections within a broader framework of strong rule-of-law protections, and used the market to efficiently distribute investments in commercialization. These countries have developed successful innovation-intensive sectors like biotechnology and information technology that have, in turn, produced widespread social and economic benefits. The experiences of these countries can provide all of us with valuable lessons and insight into how to harness effectively—and fairly—the power of technology transfer.

### 4.1 *Brazil*

The strength and durability of the Brazilian government's commitment to science education and infrastructure are impressive. The State of São Paulo Research Foundation (*Fundação de Amparo à Pesquisa do Estado de São Paulo*, also known as FAPESP) has supported basic scientific research and graduate education at several universities in São Paulo for the last half-century. The federal Ministry of Health has funded two major public research institutes: the Instituto Butantan and the Oswaldo Cruz Foundation. In recent years, the Instituto Bhutantan has been recognized for its role in the development of a hepatitis B vaccine.[8] The Oswaldo Cruz Foundation has a long and distinguished history, including historic health and sanitation campaigns against bubonic plague, yellow fever, and small pox,[9] and the foundation most recently announced advances in development of an algae-based microbiocide for use against HIV/AIDS.[10]

However, Brazil lacks market-based incentives to drive private capital into commercial development. As Michael Ryan observes, "*The Brazilian public sector has made substantial investment into university and public laboratory research, thereby establishing the potential for biomedical technology innovations, but the lack of private sector R&D capabilities and lack of public-private linkages has traditionally prevented technology from being commercialized into the marketplace.*"[11] Partly due to these weaknesses in its technology innovation system, the country's economic growth in the 1970s and 1980s faltered.[12] Currently, two-thirds of R&D spending in Brazil is funded directly by the government (for comparison, only one-third of R&D spending in the United States is funded directly by the government), and only 18% of scientists and technicians work in the private sector.[13] The dynamism and flexibility of market forces were stymied by the government's decisive intervention in the innovation process, and the resulting inefficiencies contributed to slow economic growth.

Currently, a number of reforms are underway in Brazil to encourage private sector investment in R&D activities. As a result, there are more international patent applications being filed by Brazilian companies through the World Intellectual Property Organization (WIPO) Patent Cooperation Treaty,[14] and new products are beginning to enter the market.[15] This trend should strengthen the economy and provide Brazil's people with more and better products in every economic sector.

According to Ryan, Brazil was not alone in giving a dominant role to government in the pursuit of scientific and technological development. He cites a number of large developing countries that had also followed a policy of state-led economic development. Many of these have since revamped policies to promote greater private sector investment in the commercialization of new technologies. These include China, Mexico, Egypt, India, and Turkey. The lesson here is not that government should not provide funding to develop new technologies but that such funding should be focused on basic research (which functions as a kind of "seeding" for innovations). Applied research and research focused on commercializing an innovation should rely more on investments from the private sector to ensure maximum efficiency and economic growth.

### 4.2 *Israel*

Israel is another state with a commitment to long-term investment in science and infrastructure. Recent investment data show that at least 50% of science funding in Israel comes from the State of Israel and international public sector sources.[16] Each of Israel's ministries includes a chief scientist,[17] and Israel's primary and secondary schools have a strong basic science curriculum.[18]

Israel is a world leader in areas related to information and communications technology. These technological areas do not require capital investments to the same high degree as biotechnology and are characterized by short lead-times and low regulatory barriers to market entry. In fields such as biotechnology, however, Israel is not as innovative. As Avi Molcho observes, "*Israel is among the world leaders in many fields of technology. It is a hub for innovative technologies in communications, semiconductors, information technology, and medical devices—innovation that has been translated into commercial success. While the same, if not greater, degree of innovation is found in Israeli life sciences research, this has yet to be transformed into a more mature biotechnology start-up industry.*"[19] In fact, Israel's patent prowess appears formidable: "*Israel ranks first worldwide in the proportion of life-science patents to the total number of patents written by Israeli inventors. The country ranks fourth in total number of biopharma patents granted, in terms of patents per capita, and 12th in the absolute number of biopharma patents.*"[20] Alla Katsnelson suggests that this is because patents are underutilized: "*Israeli life-sciences patents comprise almost a third of the country's total patents. What seems to be lacking is the ability to turn all this life-sciences-focused intellectual property into biotech products.*"[21]

The Milken report cites the lack of sufficient market incentives for commercialization of science,[22] while others point to relatively weak levels of patent protection and data exclusivity.[23] Some identify the market dominance of the generic pharmaceutical manufacturer Teva,[24] as one reason why Israel has not strengthened market and/or IP incentives for international biotechnology companies to enter or remain in the market.

Interestingly, Israel has maintained weaker levels of IP protection at the same time many of its neighbors, including Bahrain, Jordan, Morocco, Saudi Arabia and the United Arab Emirates (UAE), have strengthened their IP systems through WTO accession, bilateral free trade agreements and/or unilateral reforms.[25]

Whatever the reason or combination of reasons, Israel continues to suffer from a dearth of private clinical biotechnology research. David Haselkorn succinctly notes, "*Not one single [multinational pharma] company has developed an R&D center here.*"[26] The Milken Institute goes farther, stating that the Israeli biotechnology sector is in decline, "*as measured by the amount of venture capital funding.*"[27]

### 4.3 *Jordan*

Until the early 1990s, the Hashemite Kingdom of Jordan was best characterized as an aid- and remittance-based economy, with an estimated per capita gross domestic product (GDP) of about US$800. Over the past 15 years, however, the Jordanian government has increased its commitment to science education and infrastructure, improved its IP laws and the enforcement of those laws, and adopted a model of economic planning that relies on the private sector for job and wealth creation. The impact of these changes has been profound: the country has become more integrated into the world economy and enjoyed a more than five-fold increase in per capita GDP since the mid-1980s, reaching US$4,700 in 2006.[28]

The growth of Jordan's export-led pharmaceutical industry is particularly remarkable. In 2001, production in the pharmaceutical sector totaled US$180 million; in 2002, it was US$210 million; and in 2003, it reached US$275 million.[29] This was achieved both through higher levels of domestic IP protections and through trade benefits provided by the World Trade Organization (WTO) and the United States–Jordan Free Trade Agreement.[30] Jordanian pharmaceutical companies are beginning to invest more in research and product development. For example, local Jordanian companies Triumpharma and Advanced Pharmaceuticals are both investing in research to produce and patent drug delivery mechanisms. In addition, two new clinical research organizations have been established in the last three years.[31] Today, Jordan exports its pharmaceutical products to over 60 markets worldwide.

In addition, Jordan has adopted market-friendly policies that are attractive to international pharmaceutical companies. Major international pharmaceutical companies, such as Organon, Novartis, and Aventis, have worked with new Jordanian clinical research organizations and Jordanian hospitals to conduct clinical trials. Since 2000, Jordanian companies have established licensing relationships with pharmaceutical companies from Italy, Japan, Korea, Italy, Switzerland, the United Kingdom, and the United States. These foreign companies often rely on their Jordanian partners to provide marketing and distribution expertise in the Middle East. In return, Jordanian companies benefit from foreign investment by gaining a broader product base for sale, both at home and into export markets, and for the in flow of know-how and technology.[32]

The government of Jordan continues to invest in science and technology. Areas of investment include: natural products development; early diagnostics using monoclonal antibodies; applied microbiology in food; production of biogas, biofertilizers, pesticides, and yeast; and the development of new biotech equipment. Moreover, Jordan has recently established the King Hussein Cancer Center and Biotechnology Institute with support from the U.S. National Institutes of Health through the Cancer Biomedical Informatics Grid program.

### 4.4 *India*

When it comes to adopting technology-friendly policies, few countries have faced as many challenges as India. R. A. Mashelkar, recently retired as the Director General (1995-2006) of the Council of Science and Industrial Research (CSIR), an early and persistent advocate for India's adoption of technology transfer policies, calls India's history with such policies "*a series of missed busses,*" in terms of lost opportunities for leveraging India's intellectual assets in the global knowledge economy.[33]

Many have cited India's confidence in biotechnology as rooted in its earlier success in the information technology (IT) sector. It is less well known, though, that patent protection also fueled India's original IT success, in the form of Dr. Sam Pitroda's software patents.[34] In 1980, prominent nonresident Indian and software guru Pitroda sold his first U.S. company and brought the profits to India to support his dream of installing telephones throughout rural India.[35] Telecommunications has been widely recognized in India as foundational to the entire industry sector known as "Information and Communications Technology (ICT)," as well as the related sub-sectors known as "Business Process Outsourcing (BPO)" (which include back-office operations for multinational corporations, and call centers, among others) , and BioInformatics (the analytic processing of data generated as part of clinical research in the life sciences and  provided India's initiation into biotechnology).[36] Pitroda's software patents helped him to made his first fortune and provided the resources he needed to bring telephony to rural India, laying the foundation for India's IT revolution.

Now the government of India is preparing to introduce comprehensive technology transfer legislation in 2007. Under the bill, academic inventors and their institutions would share royalties, and academic entrepreneurs will be encouraged to file patents to gain both increased research funding for their institutions and individual benefits for themselves, in the form of royalties. [37] The law would also include key mechanisms to benchmark patentable research undertaken by Indian academic and research institutions with support from the government of India.[38] In the past year, product patent protection has been adopted and implemented in several fields, including pharmaceuticals. Patent processing reform has improved efficiency and reduced patent review times, and, increasingly, domestic companies are recommending that India adopt protection for commercially valuable clinical research dossiers (a protection known as *data exclusivity*).[39]

India is engaged in a cooperative internal dialogue about how to implement these IP reforms. The Indian government continues to promote India as a global biotechnology R&D hub, and the country has become a primary global location for preclinical and clinical R&D. Most recently, the 2006 Ernst and Young European Attractiveness Survey placed India among the top five countries as a pharmaceutical and biopharmaceutical R&D destination. Commercial biotechnology, which crossed the billion-dollar mark in 2005, has now reached nearly US$1.5 billion, with 36% annual growth.

### 4.5 *Ireland*

Over the past 20 years, Ireland has gone from "net brain-drain" to "net brain-gain" by systematically adopting pro-technology transfer policies and becoming a major importer of foreign direct investment in the area of life science. Ireland offers strong patents and data exclusivity for terms of up to 11 years. There is substantial government support for science education and technology-related infrastructure, and the government's corporate regulatory policies ensure greater market orientation in terms of increased moderation in labor policies,[40] reduced corporate taxation,[41] and other reforms:

*Foreign direct investment in Ireland has been attracted by low rates of corporate tax. Today, Ireland has one of the world's lowest rates of corporation tax, with the maximum rate for trading profits being 12 percent. Other factors that help attract biopharmaceutical companies to Ireland include the ready availability of the required specialist skills. Output from the third-level institutions is being continually refined to meet the sector's needs. Further, the considerable growth in the Irish economy over the past ten years has seen very significant repatriation of skilled people. In addition, Ireland is seen as a desirable expatriate location with a minimum of bureaucratic obstacles and an excellent educational system that facilitates family relocation. The free movement of labor within the enlarged European Union has facilitated the swift acquisition of a further pool of skilled people.*[42]

As a result, Ireland has become more attractive to foreign investors for biotechnology and other high technology sectors[43] and is also winning the global competition to attract and retain well-educated, creative workers.[44] More than 170 companies employ 35,000 people in Ireland's chemical, pharmaceutical, biopharmaceutical, medical device, and diagnostics industries.[45] Together, these sectors generated more than US$52 billion in exports in 2005. Ireland's per capita income has grown from about US$5,000 in 1986[46] to US$43,600 in 2006,[47] a level of per capita income that is comparable to that of the United States and the United Arab Emirates.

## 5. CONCLUSION

Technology transfer can improve lives by introducing innovations that directly contribute to improved public health, nutrition, and communications. Less obviously, but more importantly, the policies that promote technology transfer—such as an emphasis on personal rights and education—also promote economic development. Ideally, any positive changes in political and economic climate will create a self-perpetuating cycle: an improved economic environment and a general increase in education levels will lead to improved public health, which will in turn strengthen the economy.

The above overview strongly suggests that such technology transfer works best when there is strong, consistent government support of basic research—including science education and technology-related infrastructure—and robust IP protection. Government policies should also strive to encourage market guidance and private sector investment in applied research and commercialization efforts. In this way, the strengths of the government and of the market can be synergistically applied to improve the lives of all of us. ■

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1 For more background on Oliver Evans, the mechanized flour mill and other inventions, see www.greenbank-mill.org/oliverevans.html. For more about Washington's gristmill, see www.mountvernon.org/visit/plan/index.cfm/pid/806/.

2 Public Broadcasting Service. A Science Odyssey: People and Discoveries. www.pbs.org/wgbh/aso/databank/entries/bmflem.html.

3 "*An agreement was drawn up with Merck whereby the company provided chemical assistance, experimental animals for pharmacological evaluation of antibiotics, and large-scale equipment for producing any promising discoveries. In return, Waksman assigned Merck any patents resulting from research in his laboratory. Should any of the patents prove commercially successful, Merck was to pay the Rutgers Foundation a small royalty.*" acswebcontent.acs.org/landmarks/antibiotics/trials.html. Streptomycin is broadly recognized as one of the important early antibiotics. In addition to being the first effective chemotherapeutic treatment for tuberculosis, it also showed effectiveness against typhoid fever, cholera, bubonic plague, tularemia, urinary tract infections, and others. As Dr. Waksman recognized the importance of the new drug, he became uncomfortable with the agreement giving Merck exclusive rights, and Merck agreed to a renegotiated non-exclusive license and was granted a rebate on royalties to compensate the company for the cost of development of streptomycin. "*Merck was praised for its generosity and Rutgers made licensing agreements with other drug companies*."

4 See Brief of *Amicus Curiae* BayhDole25, Inc., supporting respondent in *Microsoft vs. AT&T*, pp. 14–16.

5 26 January 2004 Keynote address by Bill Gates, Chairman and Chief Software Architect, Microsoft Corporation, at the Enterprising Britain Conference, London, UK. www.hm-treasury.gov.uk/documents/enterprise_and_productivity/enter_conf/ent_entconf_gates.cfm.

6 For and extensive discussion of the debate over the issue of allowing exclusive rights to private actors to commercialize publicly funded research outcome, see *BayhDole at 25: A Survey of the Origins, Effects, and Prospects of the Bayh Dole Act*. www.bayhdole25.org/resources.The author of this chapter is a founding board member of BayhDole25, a not-for-profit organization that promotes technology transfer in developing and developed countries through education and outreach activities. For more background and information on this organization, see www.bayhdole25.org.

7 Sack DA. 2005. Letters: International Gaps in Science Publications. *Science* 309 (5739): 1325–1326.

8 Ferrer M et al. The Scientific Muscle of Brazil's Health Biotechnology. *Nature: Biotechnology 22(Suppl.)*:DC9, DC10. www.nature.com/naturebiotechnology; see also www.swissbiotechassociation.ch/files/countryprofile/Ferrer%20u.a.%20Scientific%20Muscle%20of%20Brazils%20.

9 See *supra* note 9. Historic background on the first hundred years of Oswaldo Cruz Foundation (originally

founded as the Federal Serum Therapy Institute). World Health Organization (WHO) at www.who.int/tdr/publications/tdrnews/news65/oswaldo-cruz.htm.

10 Algae Gel to Combat HIV Infection. BBC News, 29 January 2007. news.bbc.co.uk/go/pr/fr/-/2/hi/health/6266527.stm.

11 Ryan M. 2006. *Brazil's Quiet Biomedical Innovation Revolution: Drugs, Patents, and the "10/90 Health Research Gap."* Creative and Innovative Economy Center, George Washington University Law School: Washington, DC.

12 See *supra* note 5, p. 3

13 See *supra* note 5, p. 5 (citing a 2005 FAPESP report).

14 Brazil leads Latin America in terms of resident patent applications filed in the Patent Cooperation Treaty. Though it still lags behind China and India, Brazil is in the top 20 patent offices for global PCT filings. WIPO Patent Report: *Statistics on Worldwide Patent Activities, 2006*, p. 7. www.wipo.int/ipstats/en/statistics/patents/. In 2004, Brazilians filed 280 PCT International Applications. Ibid. p. 37.

15 See *supra* note 5, pp. 5–10.

16 www.ilsi.org.il/industry_financing_history.asp.

17 www.science.co.il/ChiefSci.asp.

18 www.science.co.il/SciencePolicy.asp.

19 Molcho A. 2005. Meeting the Challenges of Israeli Biotechnology. *Israel Venture Capital Journal*. 8 March 2005. www.altassets.com/casefor/countries/2005/nz7289.php.

20 DeVol R, et al. 2006. *Mind to Market: A Global Analysis of University Biotechnology Transfer and Commercialization*, The Milken Institute, September 2006, p. 188. www.milkeninstitute.org/pdf/mind2mrkt_2006.pdf.

21 Katsnelson A. 2005. When will Israeli Biotech Grow Up? *Bioentrepreneur*. www.nature.com/bioent/bioenews/092005/full/bioent882.html.

22 Ibid at p. 186–88.

23 See USTR 2006 *"Special 301" Priority Watch List*. www.ustr.gov/Document_Library/Reports_Publications/2006/2006_Special_301_Review/Section_Index.html?ht. (Retaining Israel on the IP black-list for implementing weak protection for commercially valuable clinical dossiers and curtailing patent term restoration for time lost due to bureaucratic delay in patent review, USTR "*continues to urge Israel to strengthen its data protection regime in order to promote increased bilateral trade and investment in the field of pharmaceuticals and other knowledge-based sectors.*")

24 The dominant market position of Teva is illustrated by its outsized presence on the Tel Aviv Stock Exchange (TASE), on which the market value of the company is the largest of any company in Israel and stands at five times that of the next largest company, Bank HaPoalim. See Israeli Ministry of Finance. 2005. *Capital Market Annual Review*. www.mof.gov.il/beinle/capitalmarketsreport2005final.pdf. Teva remains among the largest generic pharmaceutical producers in the world, employing 25,000 people worldwide, with a total of $5.3 billion in global sales in 2005. See *supra* note 21, p. 185.

25 See www.ustr.gov/Trade_Agreements/Section_Index.html for bilateral free trade agreements in the Middle East/North Africa region and related IP provisions. In addition, two governments, Jordan and Saudi Arabia, adopted enhanced protection for intellectual property protection as part of their WTO TRIPS accession, including strong patent protection, data exclusivity, and linkage between patent offices and regulatory bodies to prevent marketing of infringing products. For Jordan see http://www.wto.org/English/thewto_e/countries_e/jordan_e.htm; for Saudi Arabia see http://www.wto.org/English/thewto_e/acc_e/a1_arabie_saoudite_e.htm. The UAE unilaterally ratcheted up its levels of patent and data protection starting in the 2000–2002 period. See Haider L. United Arab Emirates: Agreement Set to Boost Research. *Managing IP*. www.managingip.com/Page=10&PUBID=34&ISS=20608&SID=588197&TYPE=20.

26 See *supra* note 12.

27 Citing the 19th annual Ernst & Young biotechnology report, which concludes that the medical devices sector received more investment in 2004 than did biotechnology. See *supra* note 21, p. 185.

28 For 1980s data see: Sullivan P. 1999. Globalization: Trade and Investment in Egypt, Jordan and Syria Since 1980. *Arab Studies Quarterly* (*ASQ*), 21: p. 35-72.

For 2006 data see CIA. The World Factbook: Jordan. www.cia.gov/cia/publications/factbook/geos/jo.html.

29 Ryan M. 2004. *Establishing Globally Competitive Pharmaceutical and Bio-Medical Technology Industries in Jordan: Assessment of Business Strategies and The Enabling Environment*. International Intellectual Property Institute, Georgetown University McDonough School of Business: Washington, DC.

30 The growth in bilateral U.S./Jordan trade flows provides a general example of the benefits of greater integration into the world economy through the WTO and the U.S./Jordan Free Trade Agreement. When the FTA was signed in 2000, the bilateral trade flow was not much more than a trickle: total bilateral trade between the United States and Jordan was roughly US$385 million, where U.S. exports to Jordan accounted for approximately 80% (US$310 million) of the total. *U.S. Trade Balance, by Partner, 2000*, United States International Trade Commission. swpat.ffii.org/gasnu/us/usjdfta.txt. In contrast, the bilateral trade flow exceeded US$1.7 billion for the first nine months of 2006, 2006 *Jordan Economic and Trade Bulletin*, cited in 16 *Washington Trade Daily*, 20. 26 January 2007. Jordanian exports to the United States have increased 91% since 2001. Ibid. A second general area of benefit is the increased level of foreign direct investment in Jordan since WTO accession, which grew from US$627 million in 2000 to US$2.4

billion in 2002. Haider L. 2007. United Arab Emirates: Agreement Set to Boost Research. *Managing IP*. www.managingip.com/Page=10&PUBID=34&ISS=20608&SID=588197&TYPE=20.

31 See *supra* note 15.

32 See *supra* note 15.

33 "Dr. Mashelkar has often been called a 'dangerous optimist'; so it was no surprise when he suggested that instead of being rueful of the 'missed bus' we should work on the opportunities offered by the waiting buses of the knowledge economy." *Information Pasteboard*, #IP 428/20–26 Nov 2000. www.nal.res.in/oldhome/pages/ipnov00.htm.

34 "*In fact, I spent my childhood without knowing how to use a telephone set. And I never used a telephone till I went to the U.S. to pursue my education in electrical engineering. The reason: I came from a poor background, and those were the days when telephones were locked in wooden boxes and considered an elite possession, so I never got a chance to use one. I left for [the] USA in 1964 with less than $400 in my pocket. I cherished a dream and returned to India in 1984 to realize it as a multi-millionaire with over 50 patents*." The Thursday Interview/ Sam Pitroda. 30 January, 2003, 09:01. sify.com/news/internet/fullstory.php?id=12568313.

35 Pitroda viewed telephones as just as critical to India's modernization efforts as clean water, and his Public Call Offices created a million jobs and began to change the status of the girl child. Ibid.

36 Bhattacharya M. 2003. Background paper submitted to the Committee on India: Vision 2020 . *Telecom Sector in India, Vision 2020*, p. 11. www.ictregulationtoolkit.org/en/Document.1613.html.

37 Remarks of Minister Kapil Sibal, 28 October 2006, at Hi-Tech Pune (also cited by Joshi R. 2006. Patent Rewards. *Business India* [December 31], page 30). Where IT Meets BT, Pune, Maharashtra India, www.hitechpunemaharashtra.com. See also "Patent Rewards," Business India, December 31, 2006, p. 50 ("A new law is being written to ensure that scientists in government-run laboratories will get a share in royalty when their innovation brings commercial dividends.)

38 Ibid. (Business India) (Quoting Montek Singh Ahluwalla, Deputy Chairman of India's Planning Commission: "We need to restructure our universities to make them incubation centers for research.")

39 Jyotha Datta PT. 2006. Domestic Producers of Herbal Products Seek Data-Exclusivity, *Hindu Business Line*, 12 September 2006. www.thehindubusinessline.com/2006/09/13/stories/2006091302850300.htm. See also Finston S. 2006. Data Exclusivity Brooks No Delay. *Hindu Business Line*, 18 July 2006. www.thehindubusinessline.com/2006/07/18/stories/2006071800221100.htm.

40 Glyn A. 2005. Labor Market Success and Labor Market Reform: Lessons from Ireland and New Zealand Fighting. *Unemployment*. February, 2005. www.ingentaconnect.com/content/oso/1050685/2005/00000001/00000001/art00006.

41 Ireland's low corporate tax rates include 12.5% on trading profits and an exemption for patent income, "*U.S. Multinationals Overseas Profits: Ireland's patent income tax-exemption may fund over 5% of Irish Government annual spending in 2006," FinFacts Ireland*, 21 November 2005. www.finfacts.com/irelandbusinessnews/publish/article_10003995.shtml.

42 McCarthy S. 2004. Ireland's Biotech Boom. *BIO-IT World*, citing Ireland's top ranking by the 2004 *Harvard Business Online* Global Creative-Class Index, as well as the Kearney AT. 2004. Offshore Location Attractiveness Index, which ranked Ireland fourth in the world for people and skills, and third for business environment. www.bio-itworld.com/issues/2006/april/si-ireland/.

43 See *supra* note 42.

44 See Florida R and I Tinagli. 2004. *Europe in the Creative Age*, February 2004, p.5 (noting that Ireland is outpacing all other European states in attracting creative, well-educated and productive workers in the 21st century.) www.creativeclass.org/acrobat/Europe_in_the_Creative_Age_2004.pdf.

45 See *supra* note 42. ("*Together these sectors generated more than $52 billion in exports in 2005. Nine of the world's top 10 pharmaceutical companies have major operations in Ireland.*")

46 Ireland's per capita GNP was US $4,970 in 1984 dollars, World Bank *World Development Report* 1986, p. 181.

47 CIA. 2007. The World Factbook: Field Listing; GDP per capita (PPP), 2007. www.cia.gov/cia/publications/factbook/fields/2004.html.

48 See *supra* note 47. For 2006 per capita GDP of the U.S. was U $43,500 and the U.A.E was US $49,700.