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TECHNOLOGY TRANSFER IN TRANSITIONAL ECONOMIES: THE CASE OF MEXICO

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Technology Transfer in Transitional Economies: The Case of Mexico

N. Cristina Holguin-Pando and Peter W.B. Phillips

Abstract:

Knowledge creation and mobilization is the economic driver of industrial economies, yet developing countries moving from a developing, to a developed economy, are struggling through this transition period. A variety of theories and a range of speculations have been offered as to why some nations are more innovative than others however, little of this literature examines the theoretical applicability of innovation theory based on industrial societies to developing nations. This thesis examines the theoretical rationale for applying technology transfer models developed on experiences from industrial economies to the market realities of transitional economies.

In the fifteen years since the 1994-95 collapse of Mexico's financial sector and resulting economic crisis, the Mexican economy has made impressive progress towards macro-economic consolidation and stability. The OECD (2004) observes that inflation has fallen from a rate ranging around 50% before and during the economic collapse of 1995, to a rate of about 4% in 2006. Trade liberalization that has been experienced as a partner in the North American Free Trade Agreement has allowed Mexico to consolidate its export base and to specialize in medium- and high-technology manufacturing. However, the industrial sector in Mexico still shows a lack of interest in developing, adopting and investing in technology. The Mexican industrial sector is lead by multinational firms that have located in Mexico due to the cheap costs of labour, while most of the research and development performed by these firms takes place outside of Mexico.

Innovation and technology transfer are fundamental components that drive the knowledge economy. As countries transition from developing countries to developed countries, technology transfer plays an important role in facilitating this transition. In Mexico, technology transfer is not efficient. This thesis explores the national system of innovation in Mexico by contrasting the technology transfer process against the theoretical rationale of technology transfer. This highlights the crucial barriers and challenges of the Mexican technology transfer process that will need to be addressed to facilitate Mexico's transition to the developed world.

Key Words: technology transfer, transitional economies, innovation, Mexico, R&D

Technology Transfer in Transitional Economies:
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1. Introduction

Innovations in information technologies, genetics and communication are driving global economies at an unprecedented rate. The dispersion of these technologies has not been confined to industrialized nations, as was often the case with previous innovations; instead they have reached the four corners of the earth, albeit at different speeds and different rates of adoption. Taken in combination, these three innovations have precipitated the spread of knowledge in ways that could not have been fathomed a mere twenty years ago.

As industrialized countries have embraced knowledge as the driver of the 21st century economy, innovation and the resulting products continually change our world. Many countries in the developing world are along the economic transition to a knowledge economy, which will further increase the rate of innovation and discovery, thereby driving the global rate of change at an even more rapid pace.

The rapid advancement of the knowledge-based economy in Organization for Economic Co-operation and Development (OECD) countries has been attributed to investments in science and technology (S&T), innovation policies and ultimately the mobilization of the results from such investments through technology transfer (TT) and the management of intellectual property (IP). However, little attention has been focused on the role of IP and technology transfer in transitional economies. The vast majority of the theoretical models for efficient IP and technology transfer regimes, as well as quantitative results, are predominantly based on research from OECD countries. As countries transition from developing to developed status, technology transfer is one aspect that will play an important role in facilitating this transition. To date, the literature has been largely silent on how investments in S&T and the resulting IP and technology transfer regimes can be, or should be, adopted by transition economies.

The Mexican economy has been slow to reach the stage whereby it can be considered to be in transition. The implementation of the North American Free Trade Agreement on 1 January 1994 was one of the important early initiatives that precipitated the basic changes needed within the Mexican economy. The next important step in Mexico's economic transition came in 2000, with what many considered to be the first democratic election, which broke a nearly 72 year

period of rule by a sole political party – the Partido Revolucionario Institucional (PRI) (Institutional Revolutionary Party) – resulting in increased political and economic freedom. Over the past decade, the Mexican economy has undergone slow but steady reforms that are allowing Mexico to reap a greater level of benefits from the free-trade pact with Canada and the United States. While this transition has been impressive, one wonders whether the results could have been improved. Was the economic theory for investing in scientific research and development the appropriate theory for the Mexican education system? Was the industrial theory too advanced for direct application to the economic circumstances in Mexico? Was the institutional design in Mexico one that could readily uptake advanced economic development theory and translate this into marketplace impacts?

In Mexico, technology transfer is not efficient. This thesis compares knowledge-based economic theory for IP and technology transfer based on research experiences in OECD countries against the experiences of IP and technology transfer in the case of the transitional economy of Mexico. This will provide insight into whether OECD theories can be easily adopted by transitional economies or whether they will require restructuring prior to adoption.

This thesis explores the national system of innovation in Mexico by contrasting the technology transfer process to the leading literature on theoretical models of technology transfer. This process will identify the crucial barriers and challenges of the Mexican technology transfer process that will need to be addressed to facilitate Mexico's transition to a developed economy.

The following section provides the pertinent information to this issue. Section 3 discusses the theoretical contributions to the topic and summarizes the major thoughts. Section 4 provides the results of contrasting technology transfer in Mexico, while Section 5 provides some strategic implications. Section 6 highlights the Mexican impacts. The paper concludes with some final observations.

2. Background

The advent of the new Knowledge Economy has meant that governments have had to realize the importance of measuring the economic impacts of, and the social behaviors from, innovation. Given that innovation plays a paramount role in economic growth, quantitative measures and cross-country comparison of innovation activities have become some of the most important benchmarks in evaluating a countries' position relative to international indexes.

Globalization has acquired a very strong emotive force. Some regard it as a beneficial opportunity to achieve international competitiveness and also as an inevitable and irreversible process (Stiglitz, Wolfe). Others attach to it a fear of inequity between nations as well as a threat to employment and sovereignty (source). They perceive globalization as detrimental to living standards and social progress. Globalization indeed represents risks and challenges but it also represents opportunities for developing and transitional economies.

The concept of globalization originated at the close of the 19th century, but was largely a corporate strategy. The inventiveness and cooperation among nations during, and following, the Second World War, set the stage for the enhancement of the concept. However, it was the late 1980s and early part of the 1990s that the term became commonly used and applied. It is globalization that describes the processes of international cooperation and relations around the world, as well as determining the level of international competitiveness that countries enjoy.

Within national boundaries, each country's main objectives are – or should be – to provide for the needs of its citizens. Needs such as education, health, food, shelter, safety, communications and other benefits are the main objectives of democratic governments (Canedo-Dorantes and Aguirre-Suarez). Over the past 40 years, countries have been confronted with challenges regarding the ability to manage social change, such as, controlling the knowledge base, energy sources and strengthening financial infrastructures (Canedo-Aguirre, 2005).

Decades of economic and fiscal mismanagement by the Mexican government was followed by the 1994 North American Free Trade Agreement (NAFTA) between Mexico, Canada and the United States. The objective of NAFTA was to promote a partnership among the three countries by eventually removing trade and investment barriers. While the intent of NAFTA was to facilitate trade, in reality, by the end of 1994 the Mexican economic and financial systems were facing collapse. This collapse resulted in an exponential increase in interest rates, cancelling of domestic investment and individual savings, as well as a devastating crash in the stock market that left Mexico with a devastated economy. For Mexico, it was indeed the first crisis of globalization. Some economists (source) blamed this economic 'genocide' on the excessive flow of private foreign capital accumulation, arguing that the federal government followed a neoclassic model of trade openness that only proved to be effective for those economies where the conditions for such policies were given, economies where all the production factors where present and working in equilibrium – namely the industrial economies.

In Mexico, the neoclassic model proved to have its limits, as well as it showed its incapability of achieving sustained growth, generating employment and raising life levels for the great majority of the population. It ended up deepening the problems in the business and finance sectors, causing an economic recession, concentrating income and deepening social problems. The Mexican crisis of late 1994 and early 1995 was to many the manifestation of structural problems of the Mexican economy in the globalization era and many in Mexican society believed that globalization was the cause of the economic crash. It is not difficult to agree with this sentiment given that Mexico has low levels of human capital, an unfriendly domestic business environment, large informal labour market and widespread poverty. In reality, what failed was the model of growth promoted by the government.

In 2000, Mexico completed its long anticipated transition into democracy. The federal election in 2000 ended a 72-year period of political authoritarianism. Since then, the country has experienced an increase in political freedom, its citizens have easier access to bank lending and social programs that make benefits tangible for an expanding middle class. Economic modernization appears to have cut the levels of extreme poverty.

The 2004 Economic Survey of Mexico released by the OECD in 2004, a decade after the economic crisis, highlights the actions taken and implemented by the government in the aftermath of the 1994-5 economic/fiscal crises, which resulted in the Mexican economy making impressive progress towards macro-economic consolidation and stability. The survey, concludes that the Mexican government managed to reduce inflation from more than 50% in 1995 to below 5% (2009 year estimated at 5.1%). The current account deficit, was reduced to close to 1% of GDP in 2004 from 11.10% in 1994 (Camacho-Chacon 2009) and the management of public debt had also reduced vulnerability to interest and exchange rate shocks. In the context of trade liberalization, the survey concluded that, Mexico had also managed to reverse the negative effects, and under NAFTA, the country consolidated its export base and its specialization evolved towards medium- and high-technology manufacturing (OECD, 2004). In spite of the perceived benefits, the Mexican government has been unsuccessful in achieving its promised 7% annual growth; instead, it has struggled to reach an average 2.9% growth rate since 2000 (2009 estimated at -6.5% according to the CIA Factbook, in light of the 2008 global recession) and labour productivity remains low and is decelerating. According to the OECD, Mexico has the lowest level of human capital among the member countries.

Table 1: Mexico's key facts

Mexico's Key Socio-economic facts

Territory	1 972 550 km2
Population (2009)	111 million
Pop. Density	55p/km2
GDP (PPP) 2009	1.536 trillion
GDP/capita	$14,534
GDP real growth	-6.5 (2009) 1.3% (2008)
HDI (2007)	.857 (high –developing)
Average years of school	7.2 years
Labor Force (2005)	47 million
by occupation sector	
Agriculture	13%
Industry	23.4%
Services	62.9%
Unemployment	5.6 2009; 4% 2008
Underemployment	26%
Population below poverty line (2008)	
Food based	18%
Asset based	47%
Inflation	
1994	~6%
1995	~50%
2000	15%
2009	5.1%

The industrial sector in Mexico also shows a lack of interest in developing, adopting and investing in technology; in fact, the strongest industrial sector, the 'maquiladora' sector in Mexico is led by large multinational companies that are only located in Mexico due to inexpensive labour costs. These companies perform most of their R&D activities in their country of origin or in a country where conditions for innovation are more competitive. This has resulted in a domestic industrial sector that is characterized by medium and small companies, lacking financial stability, extremely low levels of labour specialization and rudimentary means of production. At its peril, Mexican domestic industry ignores the need for incorporating high technology into their business operations.

Another important consideration is the enormous gap that exists between government entities, the scientific community and business leaders and organizations. Although Mexico has

an established network of R&D institutions and many of them have made efforts to bridge between academia and industry, there is still a generalized impression that not only the scientific and innovative capacity in the country are immature, but also that the contributions are incapable of providing tangible solutions and opportunities for the country's well being. This situation ultimately results in researchers devoting their efforts mainly to publishing their articles in foreign journals; in extreme situations, to migrate to countries where their innovating capacities are motivated.

The not-so-friendly political and economic environment, in terms of creating and consolidating businesses also plays a significant role in impeding innovative intentions. According to the OECD's Economic Survey of Mexico, interest rates in the country average 9.69% for three-month short-term loans but are zero for long-term periods. Government expenditure on R&D activities are also a concern. In the ten-year period to 2003, Mexico invested only 0.38% of GDP into R&D (GERD) infrastructure and programs; in 2006 only 0.36% of GDP was invested in R&D. This is far from the 2000 Presidential promise of investing at least 1% of GDP in R&D annually, by 2006, as stated in the Mexican National Development Plan 2001-2006, baseline document to the Mexican Special Program for Science and Technology 2001-2006 (PECyT). The PECyT also intended that the share of government investment in R&D would be 40% of GERD, while private investment would account for 60%. Such goal assumed a sustained average growth rate of 5% annually in the PECyT period.

3. Analytical Framework

Over the past fifty years, globally competitive countries have shifted from industrial economies to knowledge-based economies. Historically, growth theorists have focused on land, labor and capital as key assets for competitiveness and growth. Currently, regardless of the perspective from which it is studied, economic competitiveness and growth depends on the consolidation and management of intellectual capital, the capacity to further knowledge and to foster an innovate society (Solleiro and Castañon, 2002; Drucker xxxx). Theoretical models of growth did not engage education, and the obvious knowledge fostered by it that accrues for technological change and development, until a few decades ago. New Growth Theory posits an endogenous innovation system is the key factor for development and growth, rather than knowledge and innovation being an independent, exogenous or residual way of investment.

The evolution of growth theory from Solow in the 1950s and 1960s, to Romer in the 1980s and 1990s and more recently, Grossman and Helpman in the mid 90s, has helped establish endogenous innovation and technological change as factors for sustained increase in development, measured by input per worker. The system is fundamentally driven by factors of human knowledge and activities such as R&D.

Knowledge and technological innovation are key pillars for economic development and growth (Grossman and Helpman, 1991). Ultimately, innovation is much more than invention. Innovation most frequently occurs within systems whose aim is to transform inventions into socially-valued products, and where success is measured by the ease of which inventions are adopted into, and adapted by, society (Phillips, 2007). Innovation is characterized by the fact that society always reshapes what it uses; in turn, the ability to renew innovation is dependent on understanding the changing context in which successive innovation occurs. Innovation is thus a creative activity that takes place within an organizational and a social context and has organizational and social consequences. In essence, innovation is the entire process that results in an invention being commercialized.

Innovation drives technological change. The pace of change that characterizes the convergence of new technologies that underlie globalization is very rapid. Technology has been defined as "... information that is put into use to accomplish some task." (Feldman and Stewart, 2007: p. 6) Technology extends human potential by allowing people to achieve things that they could not have previously done. To understand technology, we must understand the relationship between the material world and the human world, between things and people (Misa, 1992). New studies in technology theory suggest that the social component has to be closely linked with its economic impact. Technological change is not simply invention and innovation; it also implies the manner in which knowledge gets applied and how it helps to satisfy needs. The entire process has a fundamental social characteristic. In the modern technological system, this argument has perhaps more weight due to the increased impact that technology is causing directly in society, creating by consequence a greater impact and relevance to the importance of appropriate innovation policy.

The spread of computing power to every corner of the developed world, the advent of new biotechnologies and the emergence of new materials and handling systems have the potential to change the way people live and work. Among the diverse fields in technology,

biotechnology – which is the manipulation of living organisms (genetic resources) to obtain a vast array of agricultural, medical, industrial and environmental products and services – represents a transformative technology that has been called the next technological revolution (Phillips, 2007; Friedman, 2004; Oliver, 2003; Robbins-Roth, 2000). Yet, doing the science well is a necessary but not a sufficient condition for firms, the industrial sector and nation-wide economic development that can flow from technological innovation. Instead, mechanisms must be in place to encourage the value-added potential of the science: so-called *technology transfer mechanisms* (Nonaka, 1995). These mechanisms have been identified to include stable and predictable macroeconomic, commercial and social policies as well as regulatory rules and laws for product approvals and intellectual property protection.

The present knowledge-based economy is characterized by knowledge playing the primary role to generate wealth. The challenge within the context of this new economic era is to efficiently extract, manage and translate knowledge for the benefit of the society as a whole. Technology transfer has been defined as "... the application of information into use where transfer is essentially the communication of information or technology." (Feldman and Stewart, 2007: p. 6) Technology transfer is influenced by national systems of innovation. The actors that contribute to consolidating innovation systems do so within international standards, generating productivity and growth, thereby offering a competitive advantage among nations.

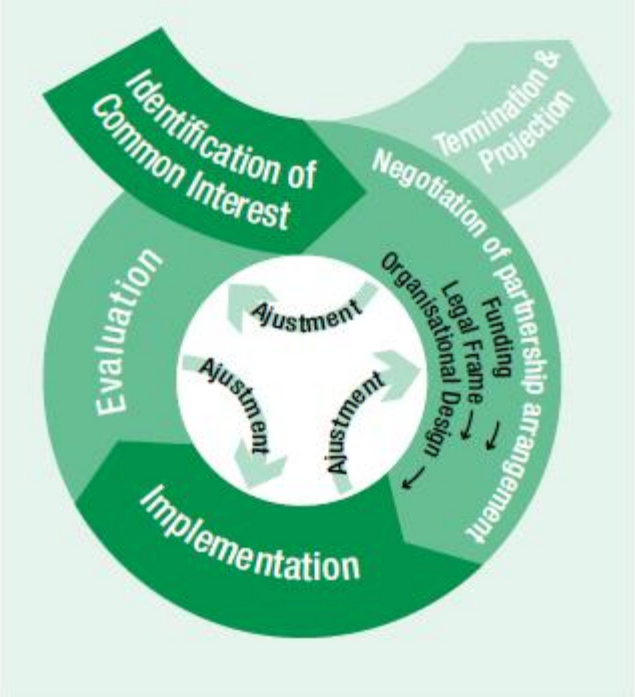
Technology transfer has long-been an important issue with the initial focus on the transfer of technologies for local use, but over time, the focus shifted on technology transfer from the industrial world to the developing world. This was lead by the efforts undertaken as part of the 'Green Revolution' (Paarlberg, *et al*., 2004). Like many streams of literature, over time there began to be a divergence in the literature as the focus expanded. This is certainly applicable to the literature pertaining to technology transfer. One field of literature that developed was the literature that focused on the relationship between innovation and the transfer of the resulting technologies.

In an article that assesses some of the public-private partnerships (P3s) undertaken by various centers of the Consultative Group on International Agricultural Research (CGIAR), Spielman and von Grebmer (2006) identify that 95% of the expenditure on agricultural research in developing nations in the mid-1990s was done by public institutions. In 1995, an estimated US$12.1B was spent on agriculture research in developing nations, with the objectives of

enhancing crop yields, improving sustainable use of natural resources and the accumulation of capital for resource-poor, small landholding farmers. Their survey of 42 stakeholders involved with CGIAR public-private partnership (P3) initiatives found that the primary barrier for these initiatives was mutually negative perceptions of both partners, while the second major barrier was identified as fundamentally different incentive structures. One of the main reasons for the mistrust from the CGIAR stakeholders was the use of non-disclosure agreements, which ran counter to the cultural concept of sharing among the public sector researchers.

In a report undertaken through the International Food Policy Research Institute (IFPRI), Hartwich, *et al*., (2007) provide five general phases of public-private partnerships (Figure 1). The rationale for the establishment of these phases is based upon an analysis of 125 P3s drawn from twelve Latin American countries. The first phase is the identification of a common interest, where the potential partners assess themselves, but also the market, the value chain and the potential sources of financing. The second phase is negotiating the partnership contract, including financing and organizational design, where the main focus is on IP, but also includes the protocols for decision-making, information exchange and evaluation. The third phase is operating the partnership itself, which is quite straightforward in that this phase ensures that the partnership remains focused on the strategic plan. The fourth phase, evaluating the partnership, is defined as assessing the short- and long-term results, the functioning of the partnership and the evolution of the partnership. The fifth phase, deciding to terminate or continue the partnership, depends in part on the initial rational for establishing the P3, so it may terminate once specific milestones are achieved or continue to operate should solid rational exist.

Figure 1: IFPRI public-private partnership model



Source: Hartwich, *et al*., (2007).

While there is a plethora of literature on the interactions between innovators and commercializers of innovation, the literature examined for this thesis relates to the transfer between public institutions and commercial interests. Frameworks exist that attempt to conceptualize the innovation systems that are used, or have been used, to enable the transfer of public sector innovations.

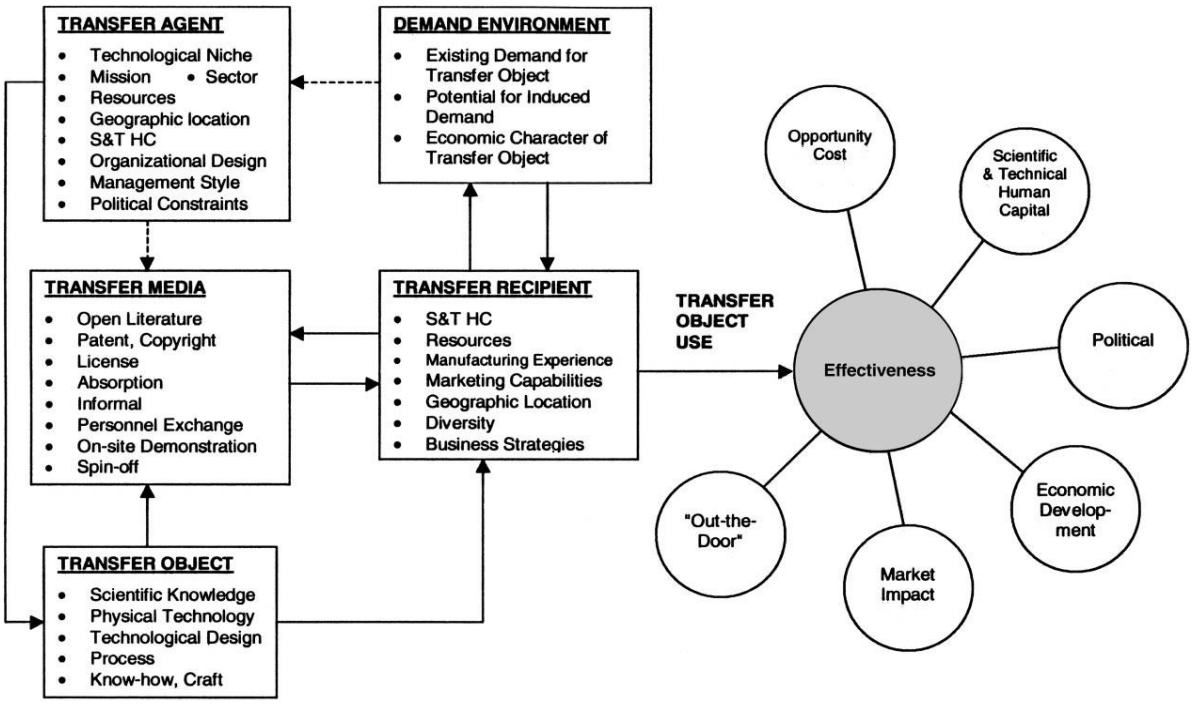
One such framework is that offered by Etzkowitz and Leydesdorff (2000). The authors provide a Triple Helix analysis model of innovation that examines the dynamics occurring between the public sector innovators of academia and government and industrial technology commercializers. Most discussions regarding the Triple Helix model of innovation analysis refer to the third version of this model, or Triple Helix III. The initial model, Triple Helix I, was very institutionalized and the relationship between academia, government and industry was largely controlled or directed by the state. The Triple Helix II relationship can be described as distinct innovation agendas with lines of communication between the three stakeholders that operated with high levels of mistrust and suspicion.

Triple Helix III is the model that most realistically represents the existing relationships in industrialized economies. In this model, distinct spheres represent academia, government and

industry, but all three spheres overlap each other. The center of this model, where all three spheres overlap, is characterized by trilateral networks and hybrid organizations (Etzkowitz and Leydesdorff, 2000). Etzkowitz and Leydesdorff argue that the common objective of this model is "…to realize an innovative environment consisting of university spin-off firms, tri-lateral initiatives for knowledge-based economic development, and strategic alliances among firms (large and small, operating in different areas, and with different levels of technology), government laboratories, and academic research groups" (p. 112).

A second framework is the Contingent Effectiveness Model put forth by Bozeman (2000). Bozeman suggests that the various parties involved in technology transfer have diverse agendas and goals and that these are achieved to varying degrees of effectiveness. The Contingent Effectiveness Model (Figure 2) examines numerous factors within five identified parties involved in technology transfer from public institutions: transfer agents; transfer objects; transfer media; transfer recipients; and the demand environment. The transfer agent is the holder wishing to transfer a technology, such as a university. The transfer object is the particular innovative product or process to be transferred. The transfer media is the avenue chosen to commercialize the technology, such as starting a spin-off company or an exclusive license agreement. The transfer recipient is the party (usually a private firm, but not necessarily) that is interested in gaining access to, or purchasing, the innovative technology. The demand environment includes market and non-market factors that will impact the transfer process, such as price for the technology or the relationship to existing technologies. Bozeman argues that this model identifies "… that the impacts of technology transfer can be understood in terms of who is doing the transfer, how they are doing it, what is being transferred and to whom." (p. 637)

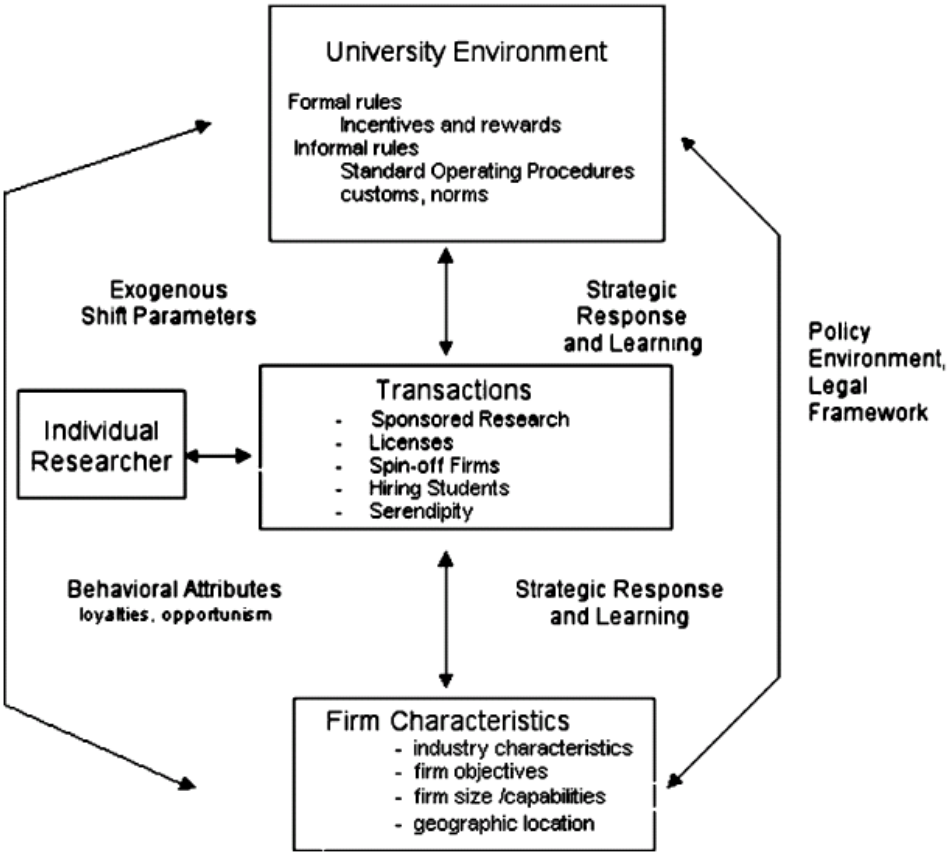
Figure 2: Bozeman's contingent effectiveness model



Source: Bozeman (2000).

A framework that focuses specifically on the transfer of university technologies is found in Bercovitz and Feldmann (2006). The authors argue that there are a variety of motivators and incentives within universities to transfer technology that is affected by economic, social and political influences. In examining the 'black-box' of university technology transfer, the focus is on "… factors that enhance or inhibit the creation and transfer of academic science" (p. 176). The University-Industry Relationship Schema (Figure 3) provides for an analysis of the dynamics that exists between the four crucial elements of university technology transfer: the individual researcher; the transfer mechanism; the firm characteristics; and the university environment. The dynamics that exist between the four principles of the schema are defined as exogenous shift parameters, behavioral attributes, strategic responses and policy/legal environments. Bercovitz and Feldmann argue that this framework highlights the "… legal, economic, and policy environments that comprise the system of innovation determine the rate and type of university knowledge production and thereby influence the rate of technology change." (p. 186)

Figure 3: Bercovitz and Feldmann's university-industry relationship schema



Source: Bercovitz and Feldmann (2006).

As Grossman and Helpman (1994) propose, economic policy makers face the difficult question of how to best promote rapid, sustainable economic growth in the face of depreciable stocks of irreproducible natural resources. Improvements in technology are the best chance to overcome the apparent 'limits of growth' (*ibid*.). Presently, innovation and technological improvements are the best choices for a country to increase its economic potential. One of the key factors for economies to truly take advantage of the benefits of globalization is to achieve a competitive level of technological development.

An *ex-post* analysis about the 1994-1995 technological competence in Mexico, indicates that the model of an open economy has not functioned as an effective and efficient catalyst for processes of transfer and acquisition of technological capacities. This model of economic openness assumes a direct and automatic relation among direct foreign investment, international markets and, on the other side, the technological capacity of the country. It is perceived that this relation only occurs to economic leaders when certain conditions are given. As the technological

capacity in Mexico was so obsolete and rudimentary, there is an obvious unbalance among the factors. The natural reaction would be then to promote technological advancement and competitiveness to compete in global markets.

Due to the diversity of agents and processes that can be defined as 'innovations' and the pieces that, in one way or another intervene in it, the innovation process is one that is complex. The simple linear model provided by basic research and applied research and development offers an interpretation of the innovation process. Over the past two decades, the model has evolved, moving from solely research and development, to include activities as broad as generation, modification and transfer of scientific knowledge and integrating technology knowledge,[1] ultimately complementing and interrelating science and technology, and projecting this interrelation to a local, regional, national and international scope.

While several frameworks for technology transfer are discussed in this section, the one that is most readily adaptable to Mexico's unique situation is that offered by Feldman and Stewart (2007). The earlier discussions of technology transfer models are based on assessments of technology transfer in industrialized economies and therefore, are too theoretically complex. Feldman and Stewart offer a linear model, or a clear representation of a logic model of innovation, that illustrates a very basic, early stage planning/adoption of a process leading to obtaining clear understanding of the stages necessary to carry forward a scientific input to a commercializable, or transferable outcome. This model, given its earliness and simplicity, can be adapted to closely represent the present technology transfer situation in Mexico (Figure 5).

[1] As a condition for the advance of science, it must absorb the advances offered by technology; more than ever, scientific discoveries depend on the instruments provided by technology development, but more fundamentally in the facility that it provides to satisfy social needs and expanding competitiveness of production systems.

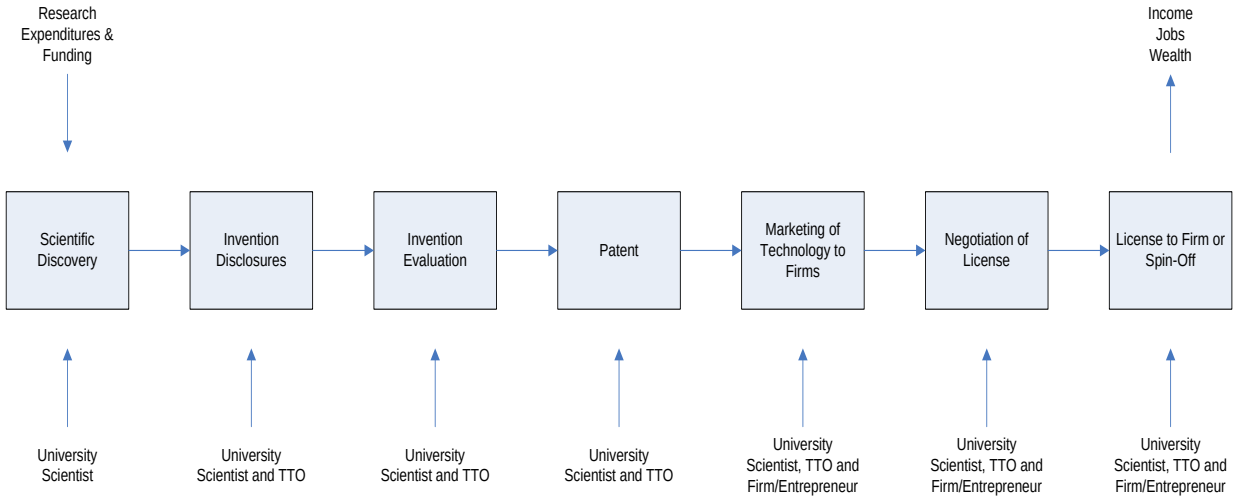


Figure 5: Flow chart of how technology is transferred from an academic institute
Source: Adapted from Feldman and Stewart (2007).

The technology transfer processes and the environment in which it exists are influenced by national systems of innovation and it is evident that they are extremely different in economies known for their innovative leadership and those with less developed characteristics, like Mexico. In advanced economies, the macroeconomic, commercial and industrial policies, as well as the regulatory system, are characterized by their stability. In Mexico, in spite of a fairly well consolidated set of institutions devoted to research and development, the innovation system is largely disarticulated. Government and its policies are in continuous opposition to the needs of the academic and scientific community and although changes have been proposed, and recently attempted, they have not yet shown major results that will open doors for complementary actions and feedback.[2] It is also important to note that the country has problems in organizing and coordinating the different levels of government, resulting in a lack of identification and focus in other social sector problems. Policies for health, education, wages, retirement and pension plans are extremely poor, causing an important shortage of human and physical capital. Mexico has to urgently address this situation since human capital is a key determinant of productivity levels, as

[2] In 2004, the Mexican Law of Science and Technology, instrumented the constitutional commitment from the Federal Government to prioritize and encourage S&T in the country. The instrument to set the framework of

well as productivity growth in the long run, in combination with innovative processes and practices (OECD, 2005).

Before moving forward with this analysis, it is important to offer a general overview of the organizational infrastructure of the main actors in the science and technology (S&T) panorama in Mexico (Figure 4).

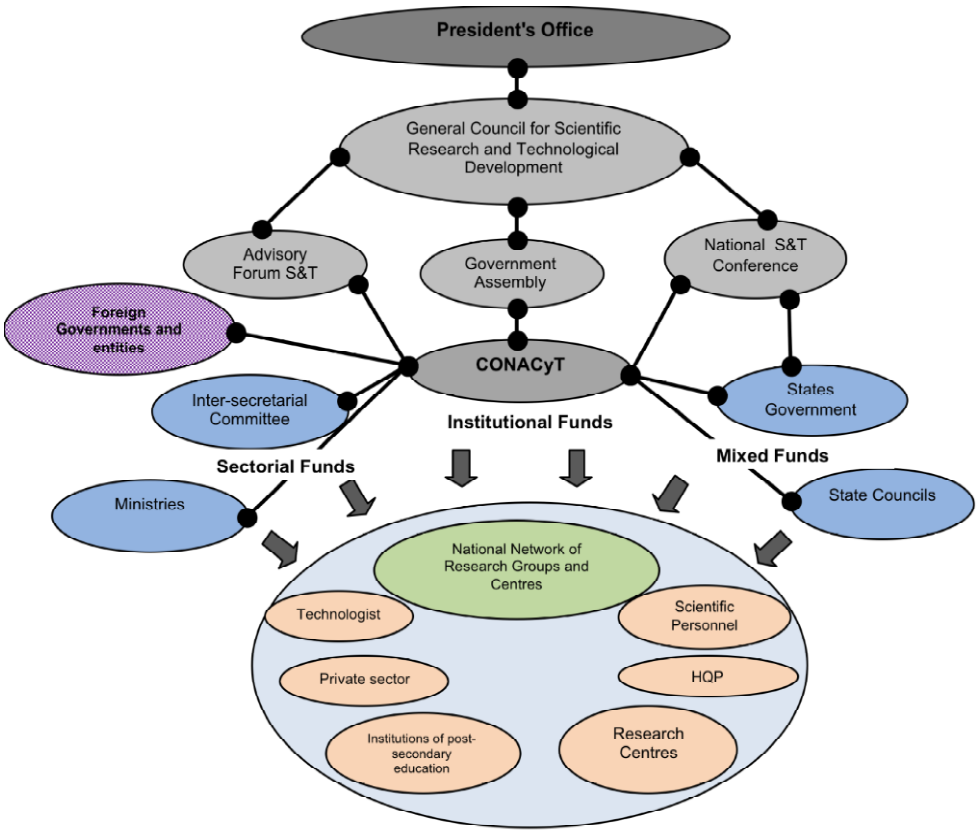


Figure 4: Mexico's National System of S&T

Source: Adapted from Conacyt 2008.

The Mexican S&T institutional structure is lead by the country's President, through the Ministry of Public Education (SEP) as the SEP is the ministry whose funding ledger accounts for S&T, as well as the SEP is responsible for the S&T policy in the country. One of the key objectives is to coordinate and foster scientific and technological development in Mexico. Its agenda is regulated and shared by a General Council, which streams down to three main groups

operation to such commitment is the *Programa Especial de Ciencia y Tecnología 2001-2006* (Special Program of Science and Technology 2001-2006). Its mandate is to offer a structural change for the National System of S&T.

of stakeholders as shown in Figure 4. Dependant of the SEP and the General Council and other 'high level' stake holders, the National Council for Science and Technology (CONACyT), formed in 1970, has the mandate to organize, coordinate and facilitate Mexico's S&T agenda. Its mission is to foster and strengthen technological development in the country by fostering scientific research, supporting technological development and modernization, establishing programs for the training of highly qualified human resources, as well as the communication and dissemination of S&T data and information.

While CONACyT provides one aspect of S&T leadership in Mexico, it is also surrounded by another layer of stakeholders who ultimately filter down decisions and operating policies to the S&T network level where the actual activities of S&T take place. This operating level is coordinated by CONACyT and it consists of the SEP-CONACyT Research and Development Centres in Mexico. These R&D centres are the main entity in which most of Mexico's scientific research is performed. There are currently 26 R&D centers in Mexico, grouped in three main categories according to their area of specialization: Natural Sciences and Engineering Disciplines; Social Sciences and Humanities; and Technological Development. CONACyT is also responsible for the administration of the National System of Investigators (SNI), whose main objective is to provide support and incentives to researchers in the public, private and academic sectors, being the latter three also important stakeholders who are considered actors in the S&T network, in an effort to stimulate the efficiency and quality of research productivity in Mexico, albeit, at various levels of coordination and functionality, which ultimately impacts their impact in contributing to the shaping of the S&T policy in the country.

Parallel to the R&D activities performed at the SEP-CONACyT Centers, Mexican universities (public and private) also play an important role in the country's R&D activities. The Sub-secretary of Higher Education and Scientific Research (SESIC), under the SEP, regulates and promotes research activities in universities and is responsible for budget allocations.

There are also other entities that integrate the S&T infrastructure in Mexico, such as state or provincial councils and agencies, as well as the commissions of S&T in the Mexican Congress and Senate, agencies that ultimately determine and move forward the S&T agenda in Mexico.

Figure 4 shows the complexity and the 'top heavy' characteristic of the Mexican National System of Science and Technology and although a very attractive potential for a discussion on governmental S&T, the focus of the following section will be concentrated on the National

Network of R&D in the country, the level where scientific discoveries are created and moved forward throughout the innovation process and resulting desirable economic potential outcome.

Following the change in government in 2000, Mexico recognized that efforts to encourage scientific research and technological development in countries are directly aligned with the degree of economic performance. In September 2004, by Government decree, an amendment to Chapter 9 (9bis) of the *Ley de Ciencia y Tecnologia* (Law of Science and Technology) established the obligation of the public and private sectors, to invest at least the equivalent to one percent of the country's GDP into S&T activities. This new addition to the law is at the core of the PECyT -*Programa Especial de Ciencia y Tecnologia 2001-2006* (Special Program of Science and Technology 2001-2006), announced by the council (CONACyT, 2001). This plan has three strategic objectives: 1) to establish a national policy in regards to S&T; 2) to increase the country's scientific and technologic capacities; and 3) to increase the competitiveness and innovativeness of the Mexican business sector.

The objective of this thesis is to contrast the effectiveness of the Mexican policy as intended by the objectives in the PECyT, in order to stimulate knowledge creation and growth relative to the country's reality and its capacity to achieve such objectives, against the Feldman and Stewart logic model of technology transfer flow. Section 4 provides a detailed assessment of the crucial factors for assessing the success of the strategic objectives.

4. Results

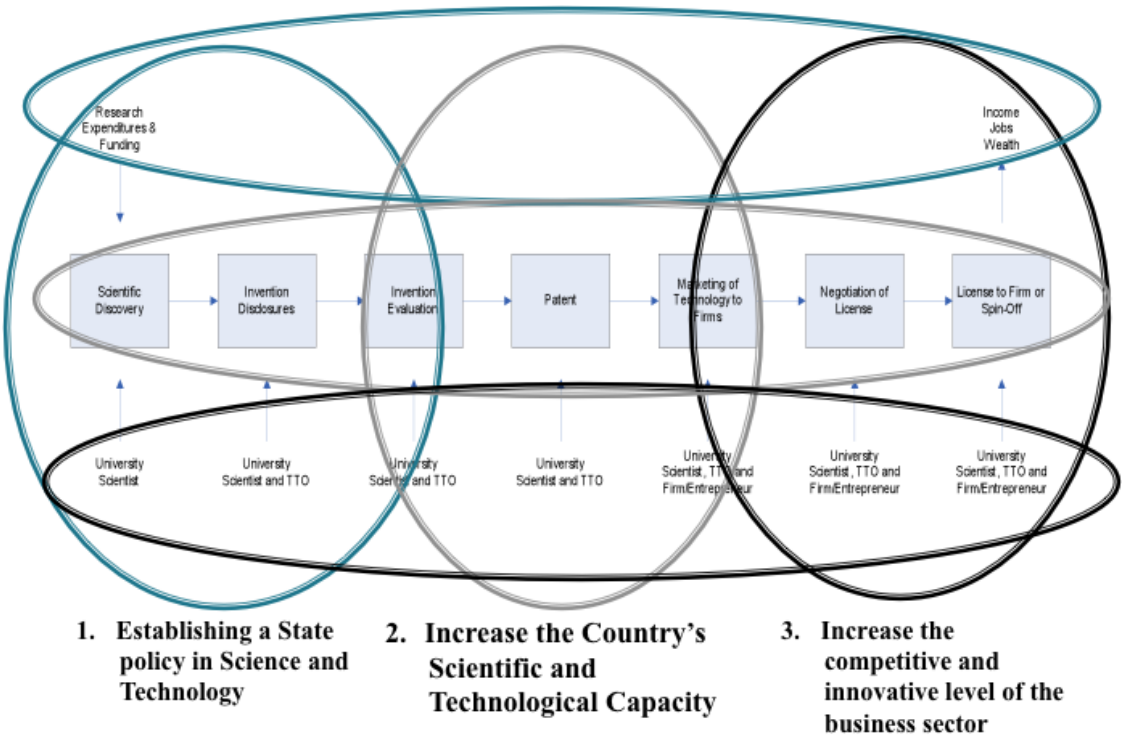
Feldman and Stewart posit that R&D and technology transfer refer to research activities undertaken primarily at universities, as these institutions are the main innovation contributors (or most commonly involved in innovative research activities) in most developed countries. As noted above, Mexico's S&T infrastructure has a distinctive characteristic in that it is mostly agglomerated into a network of R&D centres, dependant of, and reporting to, the central coordination of the SEP-CONACyT. Although to a lesser degree, there are a number of universities (e.g. UNAM, IPN and others) in Mexico that historically set up the basis for the later consolidation of the network of R&D centres, known as IES (Higher Education Institutions). For the purpose of this study as well as for comparative purposes, 'university R&D' will be considered to be R&D activities in México, carried out by the SEP-CONACyT network, as well as by IES.

The Mexican PECyT 2001-2006 contained three main strategic objectives that involved 14 strategies. These 14 strategies, which are also among the 19 main actions identified by the Mexican National Development Plan 2001-2006, are the factors that should have helped Mexico "to position itself as one of the ten most important economies in the world and among the twenty most advanced in science and technology: (PECyT, 2006).

The Feldman and Stewart flow chart in Figure 2 assumes a parallel synchronized flow of knowledge throughout the chain of actors that transform such knowledge into public goods, benefiting society and improving quality of life along the way. Knowledge is, in part, derived from education (one of the core responsibilities of government) and an innovation intensive society is dependent upon an educated society. The Feldman and Stewart model starts with the existence of scientific discovery or knowledge, which is available to flow through the stages and actors it will encounter in its lifecycle. The push of scientific discovery is dependent upon the investment of resources into a synchronized, well-connected and communicated system of knowledge creation.

Comparing the Feldman and Stewart model with the Mexican PECyT reveals horizontal similarities, where three main foundational blocks are identified as: 1) institutions; 2) resources and infrastructure; and 3) markets and adopters.

Figure 5: Mexican PECyT compared to the Feldman and Stewart flowchart of technology transfer



The first objective of the PECyT and its respective strategies can be identified as a foundational block, which in terms of this Mexican case study are represented by the country's S&T system. In the PECyT of 2001-2006, the first objective and the relating five strategies recognize the need for a well-integrated S&T system.

Table 2: PECyT first objective and strategies

Fundamental block	*Strategic objective*	*Strategies and action plan*
a. The National System of Science and Technology	1) Establishing a State policy in Science and Technology	1. Structure the National System of S&T 2. Revise CONACyT's legal framework to allow for changes in its mandate 3. Foster strategic areas of knowledge necessary for the advancement of the country 4. Decentralize the S&T activities 5. Encourage a culture of knowledge among Mexican society

The objective and strategies are aimed at promoting and consolidating S&T policy by bringing together all the existing actors of a historically fractured and disconnected S&T infrastructure, into a cohesive legal framework. Currently, the activities of S&T are centralized

by state and within different government sectors struggle to adopt the centralized policy into their own objectives and mandates, which causes a disconnection and lack of identification between government sectors, and the national S&T efforts. A decentralized approach to S&T would allow each government sector and regional entity the autonomy to adopt S&T strategies aimed at creating and strengthening sectorized and regionalized technological capacities, which together would create a synergetic force translated into national competitivenes; while the activities of S&T are decentralized, the national strategic focus would be consistent with the critical areas for the country's development, as well as it would assist in achieving an urgently needed cultural shift, more conducive to the acceptance and implementation of scientific knowledge by the Mexican society.

The existence of a cohesive S&T development system is a necessary foundation for competitive performance relative to international standards. In Mexico, there are too many layers of bureaucracy involved and directly governing the flow of resources and communication in regards to the S&T agenda. As presented above, the main knowledge generators are the centres SEP-CONACyT and a limited number of autonomous universities and specialized institutes (which receive funding from the council), yet CONACyT only receives and administers about 13% of the government expenditure on R&D (CONACyT, 2007). This dramatically limits its capacity to foster, improve and position the country's R&D activities at internationally competitive levels, thereby hindering its scientific capacity for generating knowledge.

Concurrently, at the academic institutional level there are no programs providing incentives for collaborative approaches among institutions. Existing incentives for scientific productivity are measured by publications rather than by knowledge transfer and/or training of highly qualified personnel. As well, scientific collaborations between institutions are scarce due to the lack of motivating incentives for researchers to seek affiliation with a diverse network of institutions. Such collaborations could increase access to a wider R&D capacity, including international collaboration.

Similarly, communication and collaboration between R&D centres including the IES and business and industrial sectors are not efficiently facilitated. Since the state acts as the main liaising entity to foster and encourage collaboration, a crucial barrier to the success of these efforts, is the historic mistrust from the business and industrial sectors towards these government initiatives, as well as the burdensome bureaucracy that is required to access them.

The Mexican government has taken impressive steps towards setting the foundation for a consolidated regulatory framework on which to base its S&T system. Since the 1970s however, the lack of continuity and consistency from one administration to the next has created an unstable political environment whose antagonisms create ruptures at the legislature level. When this is combined with the unfriendly legal framework for business and industrial sectors, it is virtually impossible for government to realize the targets established by successive administrations.

The second foundational block of the proposed model includes resources and infrastructure. Objective Two of the Mexican PECyT identifies the need for an increased scientific and technological capacity in Mexico. Five critical strategies (Table 3) are defined, allowing Mexico to achieve competitive knowledge creation. Once a cohesive and accessible S&T system exists, government expenditure in R&D would directly be applied by a congruent set of mechanisms, promoting investment in development areas, which are paramount for Mexico.

Table 3: PECyT first objective and strategies

Fundamental block	*Strategic objective*	*Strategies and action plan*
b. National Scientific and Technological Capabilities	2) Increase the Country's Scientific and Technological Capacity	6. Increase the national budget for activities of S&T 7. Increase the country's base of highly qualified personnel in S&T 8. Foster basic and applied R&D 9. Broaden the S&T basic infrastructure including the various levels of education system 10. Strengthen international cooperation in S&T

The OECD has indicated that in order to achieve S&T competitiveness countries would have to annually invest at least 1% of GDP on R&D activities. Mexico has struggled to reach roughly 0.38% of GDP as government contributions to the activities of S&T[3] in the 10 year period to 2003. Encouraging data to 2005 shows a slight increase to 0.46% of GDP. The federal government continues to be the main source of R&D financing, as business and private sectors investment in R&D continues to be scarce.

[3] Measured by Gross Expenditure in Research and Development (GERD).

As shown in Table 4, comparisons amongst G8 and G5 countries in relevant areas with regards to the strengthening of a S&T infrastructure, shows that Mexico is positioned at the lowest level of each indicator, which represents a clear competitive disadvantage if the country wishes “to position itself as one of the ten most important economies in the world and among the twenty most advanced in science and technology” (PECyT, 2006).

Table 4: GERD comparisons in G5 and G8 countries

Selected Countries		**Gross Expenditure on R&D**								**Researchers in full time equivalency**	
		Gross Expenditure			% Financed by Source		% Performed by				
G5+ Argentina	Year	Total (million current PPP)	% of GDP	Per mill pop.	Industry	Gov.	Industry	Gov	Higher Educ.	Total count	per thousand employment
Mexico	2005	5 919.0	0.46	57.0	46.5	45.3	49.5	22.1	27.4	48 401	1.2
Brazil*	2003	13 487.0	0.98	74.35	41.0	59.0	n.a	n.a	n.a	59 838	n.a
China	2007	102 331.0	1.46	77.0	70.4	24.6	72.3	19.2	8.5	1 423 381	1.8
India*	1998									117 528	n.a
South Africa	2005	3 654.3	0.92	76.2	43.9	38.2	58.3	20.8	19.3	17 303	1.4
Argentina	2007	2 656.2	0.51	67.2	29.3	67.5	30.3	38.9	28.8	38 681	2.9
G8											
Canada	2007	23 877.2	1.88	724.1	49.4	31.4	56	9.9	33.7	134 300	8.2 (2005)
United States	2007	368 799.0	2.68	1 220.8	66.4	27.7	71.9	10.7	13.3	1 425 550	9.7
United Kingdom	2007	38 892.8	1.79	639.9	47.2	29.3	64.1	9.2	24.5	175 476	5.6
France	2007	43 232.6	2.08	680.0	52.4	38.4	63.2	16.5	19.2	211 129	8.3 (2006)
Germany	2007	71 860.8	2.54	873.5	68.1	27.8	69.9	13.9	16.2	284 305	7.1
Italy	2006	19 678.1	1.13	333.9	40.4	48.3	48.8	17.2	30.3	88 430	3.6
Japan	2007	147 800.8	3.44	1 156.8	77.7	15.6	77.9	7.8	12.6	709 974	11.0
Russia	2007	23 482.0	1.12	164.8	29.4	62.6	64.2	29.1	6.3	469 076	6.6
OECD Total	**2007**	**886 347**	**2.3**	**748**	**64**	**29**	**70**	**11**	**17**	**3 997 466**	**7.4 (2006)**

Source: OECD Main Science and Technology Indicators volume 2009/1
*Source: UNESCO

Research and development activities in Mexico are performed mainly by government sectors with no signs of technological or knowledge mobilization to the business, industries or private sectors. Additionally, to increase the scientific and technological capacity, Mexico would have to aggressively promote the incorporation of science to the labour market. The data in Table 4 shows that the ratio of researchers per thousand employed citizens is only 1.2; Mexico is far from being a scientific and technological society. At the same time, Mexican researchers considerably lag in regards to the impact of their knowledge contributions in the global context. Table 5 presents scientific productivity of peer reviewed articles among G5 and G8 countries.

Table 5: S&T productivity by publications in G5 and G8 countries

Scientific Productivity in Peer Reviewed Publications				
	Publications 1997-2006		**Citations**	
G5 + Argentina	Total country	% of world	Total 2002 - 2006	Impact Factor
Mexico	52 029	.68	87 291	2.88
Brazil	113 801	1.49	206 231	2.95
China	365 207	4.79	692 283	2.77
India	185 228	2.43	256 450	2.40
South Africa	n.a	n.a	n.a	n.a
Argentina	43 494	.57	79 153	3.31
G8				
Canada	349 405	4.58	1 028 532	5.45
United States	2 561 910	33.59	8 937 644	6.67
United Kingdom	684 059	8.97	2 158 717	6.13
France	471 030	6.18	1 266 844	5.23
Germany	655 451	8.59	1 955 974	5.74
Italy	327 413	4.29	927 466	4.39
Japan	698 975	9.16	1 581 619	4.39
Russia	n.a	n.a	n.a	n.a
World Total	7 627 577	N/A	N/A	N/A
Source: Institute for Scientific Information, 2007 cited by CONACyT (2007)				

Mexico has the opportunity to increase interest in activities of S&T by promoting its importance among its young population, however, unless such activities also meet with a conducive structure to keep students in the classrooms, Mexico will continue to lose ground to a number of emerging nations, as China, Argentina, South Africa and others have made impressive strides towards positioning themselves in the global S&T sphere.

Objective Three focuses on the markets and adopters of S&T activities in Mexico. The objective and its strategies are concentrated towards increasing the competitiveness of the business sectors by facilitating and strengthening the processes of commercial innovation.

Table 6: PECyT third objective and strategies

Fundamental block	*Strategic objective*	*Strategies and action plan*
c. Competitive and Innovative Business Sector	3) Increase the competitive and innovative level of the business sector	11. Encourage private sector investment in R&D 12. Promote technological development and R&D participation among companies 13. Promote the incorporation/hiring of scientific-technical personnel in companies 14. Strengthen the infrastructure aimed at supporting and fostering competitiveness and innovativeness among companies

This third objective represents a major challenge under the current framework and design of the Mexican S&T system. If it were possible to isolate this objective with its four strategies and analyze it separately, the magnitude of the required effort to promote a shift in management practices from the business sectors would require years of educational efforts in order to prepare the Mexican society to be willing and ready to invest in R&D for competitive purposes. Table 4 shows the minimum participation of the business sector as a key promoter and user of S&T. Furthermore, Table 7 shows the outputs of the S&T activities in Mexico, relative to the G5 and G8 context.

Table 7: Patent data in G5 and G8 countries

Scientific Productivity by Patent Applications							
Country	**# triadic patents (2007)**	**Total Patents Applied in the Country (2004)**			**Ratios****		
G5 + Argentina	Total	Total	Residents	Non-residents	Dependency	Auto sufficiency	Inventiveness Coefficient
Mexico	20	13 194	565	12 629	22.35	.04	.05
Brazil	n.a	18 692	3 892	14 800	3.80	.21	.60
China	591	n.a	n.a	n.a	n.a	n.a	n.a
India	n.a	n.a	n.a	n.a	n.a	n.a	n.a
South Africa	29	n.a	n.a	n.a	n.a	n.a	n.a
Argentina	9	4 602	786	3 816	4.85	.17	.21
G8							

Canada	706	37 227*	3 929*	33 298*	8.47	.11	1.63
United States	15 923	356 943	189 536	167 407	.88	.53	6.38
United Kingdom	1 645	29 954	19 178	10 776	.56	.64	3.22
France	2 468	17 290	14 230	3 060	.22	.82	2.35
Germany	6 146	59 234	48 448	10 786	.22	.82	5.87
Italy	756	n.a	n.a	n.a	n.a	n.a	n.a
Japan	14 605	423 081	368 416	54 665	.87	.87	28.80
Russia	66	n.a	n.a	n.a	n.a	n.a	n.a
OECD Total	49974	N/A	N/A	N/A	N/A	N/A	N/A

n.a = not available; N/A =not applicable; * =data for 2003
**Dependency ratio= patent applications by non-residents/residents; Autosufficiency ratio= patent applications by residents/total country; Inventiveness coefficient= patent applications by resident/10,000 population
Source: OECD Main S&T Indicators 2007 and 2009
Source: IMPI, WIPO, CONACyT 2007

The transfer of technologies represented by the mobilization from basic research inputs into outcomes in the form of patents is at the core of this analysis to investigate Mexico's potential to become a key player in the knowledge economy. Under the premise that countries should look for endogenous innovation in order to achieve high levels of international competitiveness, as well as better economic performance. The data presented in Table 7 shows important disadvantages for Mexico. The large majority of patent applications in Mexico is made by non-residents, a manifestation of the lack of dynamism in the interaction between R&D and the business sectors. This has a two-fold effect. On one hand the absence of any significant intellectual property limits the potential to generate resources to further basic research activities. On the other hand, the high degree of dependency of the S&T system in Mexico on external resources limits choices in moving forward. As Table 7 shows, Mexico's patent ratios compared to those of its G5 and G8 counterparts are worrisome; for each patent application filed in Mexico by a Mexican resident, 22.35 applications are filed in the country by non-Mexicans. At the same time, the auto-sufficiency ratio of Mexican residents' applications, relative to the total patent applications in the country is even lower, at 0.04 and the measure of inventiveness of the Mexican population, observed by the limited 0.05 patents filed by Mexican residents per each 10,000 of population.

Another measure of the dynamism of domestic technology transfer activities is offered by the Technology Balance of Payments (TBP), which analyses all the activities related to the international commercialization of goods of S&T. The OECD (xxxx; xx) defines this as

> the technology balance of payments (TBP) registers the commercial transactions related to international technology and know-how transfers. It consists of money paid or received

for the use of patents, licences, know-how, trademarks, patterns, designs, technical services (including technical assistance) and for industrial research and development (R&D) carried out abroad, etc. The coverage may vary from country to country and the TBP data should be considered as only partial measures of international technology flows.

Table 7 shows comparative data for G5 and G8 countries; once again, not only does Mexico face important and urgent challenges within its national boundaries to realize technological advantages, as presented by the information about patents in Table 7, but internationally as well. The country's Technology Balance of Payments depicts a grim perspective and confirms the information offered above; Mexico is an importer of technologies, rather than being an important supplier of them. The Mexican TBP is $US-1,913 million with a coverage ratio of 0.09. In short, Mexico depends almost in its entirety on imported technologies to address technological needs in the country, which seriously limits its growth options and potential to gain from innovation.

Table 8: Technology balance of payments for selected G5 and G8 countries

Technological Balance of Payments (million USD)				
G5 + Argentina	Year	Receipts	Payments	Coverage ratio
Mexico	2005	180	2 094	.09
Brazil	n.a	n.a	n.a	n.a
China	n.a	n.a	n.a	n.a
India	n.a	n.a	n.a	n.a
South Africa	2006	46	1 279	.03
Argentina	2003	18	355	.05
G8				
Canada	2006	2 514	1 358	1.9
United States	2007	85 919	48 957	1.8
United Kingdom	2007	34 622	17 816	1.9
France	2003	5 188	3 234	1.6
Germany	2007	42 739	38 350	1.1
Italy	2007	5737	4 619	1.2
Japan	2007	21 080	6 034	3.5
Russia	2006	529	1 138	0.5
Source: OECD Main S&T Indicators, 2007; OECD Main Economic Indicators per country, 2007.				

This section has offered an analysis of the three objectives of the PECyT from 2001-2006, against the linear technology transfer model selected for its relativiness power complexity and better fit with the Mexican reality. Data has also been provided to measure Mexico's S&T performance relative to other transition economies, as well as a selected group of developed nations (respectively the G5 and G8 blocks). The next section will contrast these results against the earlier methodology.

5. Strategic Implications

The linear technology transfer schema proposed by Feldman and Stewart, identifies an efficient and fluid system to move an innovative technology from one phase to the next. To a considerable extent, the three PECyT objectives attempt to establish a similar linear, efficient and fluid system of innovation and technology transfer in Mexico. This section offers a critical assessment of each of the three objectives, by highlighting gaps in the PECyT objectives and strategies as compared to the Feldman and Stewart schema.

The flaw of the first objective and strategies seems to be that while the Mexican government continues to revise, reform and restructure its S&T system, it does not appears to have achieved a truly nationally integrated system. Science and technology development is not seen as a separate, independent institutionalized sector of the country's development plan, but rather as a paramount component and indicator of each of the main priority areas of development. Science and technology needs to be an integral piece of every government sector, so that policies can move forward with greater certainty. As it stands, the legal framework for the S&T system, fails to align with policies on economic growth, social growth, infrastructure, foreign and trade policy, among others.[4] Without this integration, where each stakeholder in the governmental structure identifies the importance of S&T for development and at the same time abandons the historic practice of competition, the country will continue to experience failed attempts to set an acceptable framework at the core of the S&T model.

Growth literature propose, and it has been generally accepted by competitive nations that in order to compete and succeed in the global scheme, in regards to S&T, countries must commit

[4] The respective government departments responsible for policy development of such sectors, namely, Secretaries of Education, with respect to the education system in the generation of knowledge and the quality and delivery of programs; the Secretary of Economy, Trade, Tax and Revenue; Secretary of Communications and Transport; Secretary of Human and Social Development; and the Secretary of Foreign Affairs and Relations.

to invest at least 1% of their GDP to the activities of R&D, in order to strengthen their domestic technological capacity. Although objective 2 of the PECyT had this goal at its core, the reality presented by the analysis of the relevant indicators, it can be inferred that Mexico has failed to meet its objective. The country's investment in the promotion and consolidation of its scientific capacity has lagged relative to other emerging and transitioning economies. Once a system of innovation is properly structured, the investment of resources in S&T education, as well as in proper systems to transfer the results of the benefits of such investments, will be crucial if Mexico is to take part in the knowledge economy, with an active role in contributing to the creation and transfer of such knowledge and innovations.

Once the system of innovation is ready to transfer its outcomes into newly commercializable goods for the benefit of society, a strong bridge must exist with the business sector in order to succeed in the technology transfer activities. The analysis of the objective 3 of the PECyT, which calls for a competitive and innovative business sector, reveals another important area of opportunity for the country. The Mexican business enterprise is not actively involved in the activities of S&T; it has minimal participation in the financing of activities of R&D, and according to the OECD, Mexican companies do not contribute to the development of new technologies, but rather adopt what is already available. The country must create incentive mechanisms so that the business sector actively participates and increases their stake in R&D, as well as in the results.

This study began as an analysis of technology transfer potential for Mexico, as a transitional economy, in order to reap the benefits and promise of the knowledge economy and in light of the countries' positioning to engage in the post-globalization era. Throughout the investigation efforts, literature review and interdisciplinary analysis focused on the factors and flaws believed to be exclusively inherent to the subject of technology transfer; it became increasingly evident that in order to be ready to truly reap the benefits of technology transfer in the knowledge economy, Mexico must transform its policy approach to S&T as a whole. Before the country can begin to worry about transference of technology goods and services, both to its own society and in search of competitiveness through international standards, as such established by the OECD, it is clear that is must achieve a coordinated functioning of the National System of Innovation. This study opens the door for a valuable contribution in matters of governance of the Mexican innovation system, from a public policy perspective.

6. Impacts on Mexico

In 2007, Mexico announced its *2007-2012 Plan Nacional de Desarrollo* (National Development Plan), in which strategic focus is given to the importance of creating the conditions in the country to be positioned at the spearhead of the global technological sphere. The 2008-2012 Programa Especial de Ciencia, Tecnologia e Innovacion (PECiTI) (Special Program for Science, Technology and Innovation) seems as a new 'polished' version of the 2001-2006 PECyT analyzed herein and a valuable contribution to the literature would be to assess this policy to identify what gaps, if any, have been addressed – or missed, from the 2001-2006 PECyT.

As offered by this thesis, the current state of the S&T system in Mexico revealed the difficulty to conduct the present study and proved a challenging effort measuring the efficiency and effectiveness of the countries attempt to create, mobilize and reap benefits from domestically generated scientific capacity and products, from research institutions to the industrial and private sectors, ultimately for the benefit of the Mexican society. Mexico's reality in the S&T context manifests the country's immaturity to compete in the global sphere with industrialized nations. This thesis moved from the search of an adaptable model of tech transfer, search which assumed existence of research products and scientific knowledge in Mexico, and which economic value would help the country to obtain financial benefits for its society, to be a fundamental policy analysis. The literature reviewed fro this study proved to have its limits to the developed world, while it opened the door for a valuable contribution to public policy development in developing countries, with focus on competitiveness in the knowledge economy.

Technology transfer efforts and the respective literature abundantly available show that a degree of caution must be observed when testing theoretical models that have resulted from contributions drawn from diverse and very advanced economic realities. The developed-developing country dichotomy proves to hold also when comparing models of S&T. Most technology transfer theory has stemmed from the experiences in industrialized nations whose sound financial and economic policy and management allow for a cohesive and relational functionality of all the actors in their respective S&T systems. In a developing, or transitioning economy such as Mexico, with a high degree of economic vulnerability and lack of sound social,

political and economic policies in place, any economic growth based in knowledge generation would prove a futile effort.

7. Conclusions

The lack of financing for R&D activities creates a domino effect, which moves from one sector to the next. Without capital investment, there is simply no inventiveness and the potential for new discoveries, processes of innovation and the translation and mobilisation of knowledge are stiffled. There is no expectation of S&T being an alternative approach to economic development and thereby promoting and achieving social well-being. At the same time, government efforts at bridging the gaps with the business and industrial sectors, as well as their effort to strengthen their communication channels and create synergies while identifying areas of development, are crucial for the social and economic betterment of Mexican society. This course of action would provide incentives for increased investment in S&T, moving the financing of this activity from the state, to the private sector.

The assessment of the three PECyT objectives and their related strategies highlights the fundamental, structural gaps in Mexico's S&T strategy. The lack of success from the 2001-06 plan is underpinned by the lack of trust that exists between industry and government. This is a basic societal challenge that is present in many, if not all, transition economies. This underlying issue has to be addressed if transitioning economies are to develop and advance. As this study suggests, the literature about technology transfer, as well as the majority of the proposed models do not hold true with the reality of developing or transition economies. This analysis about Mexico serves as an example of the need to study a broader set of factors that are present in developing countries, which may not be in the industrialized world, rather than transplanting models developed from economies where systems are conformed by a different set of factors, which include at the core, sound and mature policy development.

Further research is necessary in order to unveil the core of the issue. An analysis of policy development in Mexico is needed in order to understand the lack of functionality and effectiveness of the institutions that promote and move forward the S&T agenda in the country. A common denominator in the analysis of the models explored by this thesis is a marked relational characteristic among the pieces that compose each model. As the search for an

adaptable model to illustrate the Mexican potential resulted in the flow chart offered by Feldman and Stewart, an under laying characteristic of independency of each of the pieces was evident. This is not surprising as there is an obvious lack of cohesiveness moving forward of the system as a whole, as manifested by the results presented. The PECyT 2001-2006 failed to deliver its highly publicized strategies and achieve its strategic goals. As the country continues to transition, once again in the wake of financial crisis and global recession in 2008-2009, a new S&T plan was launched in 2007. The Programa Especial de Ciencia, Tecnologia e Innovacion 2007-2012 – PECiTI (Special Program for Science, Technology and Innovation). A deeper policy analysis and fundamental changes to the policy framework on which such effort is founded is critically necessary, or the hope for success of the new program and onwards advancement would be difficult to achieve; Mexico needs to reform its policy framework if it is seriously interested in joining in the synergetic dynamism of the knowledge based economic era.

8. References –separate file (working)