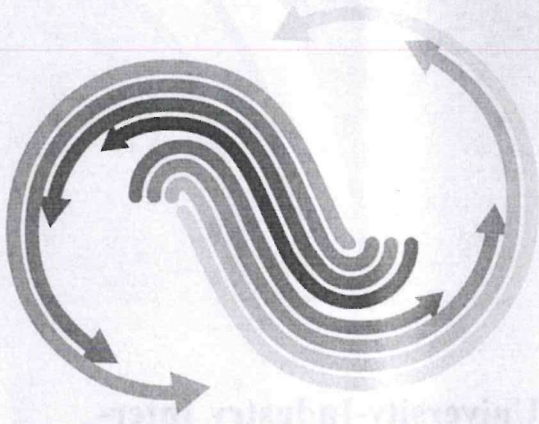UNIVERSITY-INDUSTRY
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Collaborative Innovation

THE ROLE OF HUMAN CAPITAL IN UNIVERSITY-BUSINESS COOPERATION: THE CASE OF MEXICO

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Abstract

Historically, the interaction between industry and academia in Mexico has been extremely weak. Stylised facts blame the interest of university scientists to perform basic research, which, supposedly, stem from an absence of entrepreneurial motivation in academia. However, available data shows that the capacity of Mexican firms to absorb university knowledge remains limited because of industry's scant human capital. The aim of this paper is, therefore, to examine the actual capacity of Mexico's business enterprise sector to take advantage of universities' knowledge spillovers. In doing so, a research question is posed: To what extent are Mexican productive firms really able to absorb the knowledge produced at universities? Drawing on data collected from the most recent innovation survey carried out by the National Council of Science and Technology, it is possible to estimate the human capital requirements of the Mexican manufacturing sector. Preliminary results suggest that large firms are more capable of absorbing the knowledge generated by universities, whereas the smaller firms badly need engineers and technicians to address their innovative endeavours. The implications of these results for public policy is that collaboration between university and enterprises can be enhanced by supporting the hire of relatively low-trained technicians rather by the hire of highly qualified researchers.

1 Introduction

Due to the 2008 financial crisis, most of the world's economies are still facing socio-economic risks and challenges. Then, governments are pushed to spur economic growth aiming at stabilising national debts and containing unemployment. Nonetheless, the recovery path looks knotty thanks to the unprecedented pace and scale of globalisation. That is, international trade, economic integration, and the geographic fragmentation of production processes now determine global value chains that operate on widespread collaboration, but increasing international competition from China and India has been eroding the economic and technological lead of Western economies, especially that of the United States (Deaton, 2012). In addition, environmental pressures and the longer life expectancy of people are putting a greater strain on the capability of economic systems to meet the needs of their citizens (OECD, 2013b).

No wonder that innovation is increasingly seen as an engine for effectively achieving economic growth, especially for emerging nations like Mexico. Even though the business enterprise sector is at the heart of innovation, firms require co-operative efforts from national and international agents, and Mexico's public policies have not yet been sufficiently efficient as to promote competitiveness across the economy. According to the Organisation for Economic Co-operation and Development (OECD, 2009), there are large disparities in Mexico's income levels due to poor productivity performance in many sectors. Hence, a key question for Mexico is whether public policy would support the development of its national innovation system generally, and, if so, could it address the development needs of lagging sectors as well? Mexico badly needs to spur its industrial and technological capabilities in order for productive firms to adapt knowledge for their innovation needs (OECD, 2013a).

Because of the dramatic decline in standards of living, and attempting to avoid a total collapse of the scientific community, the government created the National System of Researchers (SNI) in 1984. The original aim of the system was to supplement the salaries of the most productive researchers (OECD, 1994). Over the years, the programme has consolidated and become a distinguishing feature of the Mexican scientific and technological community. At the beginning (1984), the number of SNI researchers was close to 1,400, reaching more than 18,000 in 2012. According to González and colleagues (2007), in 2003, about 30 per cent of Mexico's researchers were at the SNI, and they published about 85 per cent of the Mexican international peer-reviewed publications in the ISI Thompson Web of Science Database. The problem with this situation is that Mexican scientists nowadays receive a sizeable part of their incomes by being part of SNI, making them financially too dependent on the system's membership (Esteinou, 2013).

Once the financial turmoil ceased, the Mexican science and technology policy adjusted to the newer conditions. The country moved from the import substitution model towards a deregulated and privatisation-prone model. In 1985, Mexico became a member of the General Agreement on Tariffs and Trade (GATT), and in 1994 signed the North America Free Trade Agreement (NAFTA). Thanks to these changes the country received a loan from the World Bank in 1991, aimed at enhancing the science and technology system. This loan facilitated the creation of the Support Programme for Science in Mexico in 1992 (PACIME). PACIME helped to embrace several different initiatives such as the programme for supporting research projects, the fund for strengthening the science and technology infrastructure; the fund for retention and repatriation of Mexican researchers and the fund for establishing endowed chairs of excellence. Other important science and technology programmes were also launched by CONACYT at that time, such as the university-industry linkage programme and the technology-based firm incubators (OECD, 1994). As a result, science and technology investment grew considerably. For example, government expenditure on science and technology, as a percentage of gross domestic product (GDP), increased from 0.28 per cent in 1990 to 0.33 per cent in 1991, but public funding has not yet been able to pass the 0.5 per cent mark (OECD, 2013a). Nonetheless, CONACYT saw its budget increase more than 230 per cent in real terms during those years (González et al., 2007).

In the 1990s, the main policy objectives aimed at enhancing the country's research potential by supporting advanced training, together with technological development. As a result, scientific productivity experienced a noticeable bust, with Mexican researchers publishing more papers. According to González and colleagues (2007), the participation of Mexican scientists and engineers in the global scientific production increased from 0.2 per cent in 1993 to 0.5% in 2003.

In the new millennium, scientific and technological production had grown in Mexico by several measures: in size, output, and international impact, but these achievements were not sufficient to catch-up with those pertaining to similar economies. According to OECD figures (OECD, 2009), gross research and development (R&D) expenditures as a percentage of GDP was 2.65 per cent in the United States, 1.58 per cent in Canada, but remained at 0.40 per cent in Mexico, ranking the country as the worst member among OECD countries in terms of resources devoted to science and technology. This situation is not totally fair, however, because Mexico is ranked in 25th place in terms of gross expenditures on R&D, as reported by the Battelle Memorial Institute.

Because the amount and quality of Mexican scientific research grew only slightly, CONACYT launched several programmes to foster industry innovation in order to shift the emphasis on pure scientific research. These programmes included the R&D Technological Modernization Trust Fund (FIDETEC), which was established to provide warranties and long-term financing for pre-commercial R&D. Other programmes sought to encourage the creation of technology-base incubators (PIEBT), the support of private research centres (FORCCyTEC), and to improve technology information (RCCT). However, funds' scarcity, together with high interest rates, lack of experience in evaluating financial risk, and poor design led to low demand, resulting in a very modest impact. Besides, the scant impact of these programs was also due to the extremely low investment of the business sector in innovation activities, in particular R&D. In this respect, González and colleagues (2007) argue that the long history of economic protectionism in Mexico created a social environment with very little appreciation for innovation.

In order to cope with these shortcomings, a new legislation was introduced in 2002. The 2002 Science and Technology Act sought to fix several institutional inconsistencies in the Mexican system of innovation (Merritt, 2004). Although the Act generated huge expectations among the scientific and technological community, they were never fulfilled. Firstly, the government did not take care of the small print in the legislation that otherwise would have driven the necessary policy actions towards success. Although the 2000-2006 administration declared that it was strongly committed to science and technology development, with the president even publicly saying that he had a commitment to led R&D investment to reaching 1 per cent of GDP by 2006, the regime was unable to keep its promise due to its lack of political will (González et al., 2007)

From 2002 onwards, CONACYT has been devoted to administer several governmental programmes. Among the most celebrated is the Last Mile Initiative, which targeted fiscal resources to support pre-competitive projects. Another one is the Entrepreneurs Fund Programme, with only nine companies receiving financial support by the end of 2005. Yet, the number of applicants was extremely low considering the size of the business enterprise sector (OECD, 2009).

Nowadays, the current regime has publicly announced that it seek to carry federal expenditure on science and technology to the long-awaited 1 per cent of GDP. At the light of the past results, one should not expect a different outcome, however. The problem lies on the heavy burden for the public purse because of the growing increases in the SNI membership and the foreign-oriented scholarship programme, which tend to drain most of CONACYT's current budget. Without a change in the attitude of the private sector towards science and technology, public funds will remain insufficient to meet national demands on innovation. The following sections deals with the structure of the Mexican education system.

3   Science and Technology Education in Mexico

The Mexican Constitution guarantees every individual the right to education, through Article 3 of the Constitution. The General Education Act provides the basis for the national education system. Moreover, the State is responsible for providing, free of charge, an education based on the principle of freedom of belief and directed towards the economic and social improvement of the population, but private institutions may provide education of all types and at all levels, as long as their programmes are recognised by the government (Bradley, 2010).

Mexico has four main types of educational institutions: federal public; state public, autonomous public, and private. Private institutions must be officially accredited by the Secretariat of Public Education (SEP), by the corresponding state government, or through accreditation by the National Autonomous University of Mex-

On the other hand, Mexico's higher education policy needs to engage with industrial innovation. Although universities play a vital role in supporting productive clusters and innovation systems in many OECD nations, in Mexico, this "third mission" of entrepreneurial engagement is underdeveloped. While the Secretariat of Public Education does not explicitly use policy to promote engagement, other federal actors, such as CONACYT and, to a lesser extent, the Ministry of Economy through the SME Fund, do offer incentives. According to the OECD (1994; 2009; 2013b), Mexico must increase the industrial engagement of its universities. This can be done by adjusting its higher education policy to support cluster-based approaches with a focus on specialized training and research.

While many universities worldwide have increasingly adopted managerial approaches in order to cope with the growing technical demands from industry, many developing nations are still reluctant to reform their universities due to vested interests and institutional inertia (Hazelkorn, 2005). Besides, reforms are not easy to announce, nor to implement because changes have often been divisive. As pointed out by Connell (2005), there exists an underlying tension between the collegial and the managerial approaches to decision-taking in most universities, and these tensions tend to grow as universities establish closer linkages with external organisations, including business and industry.

Mexican universities are now facing growing demands for accountability. Not surprisingly, many of them have recognised that radical changes can be unavoidable, so resolving the tension between the pursuit of financial autonomy and academic freedom remains a continuing challenge for their institutional setting. The following section deals with the co-operation between universities and the business enterprise sector.

4   The Promotion of University-Industry Links

Active collaboration between industry and academy encourages knowledge transfer. The nature of university-industry partnership is complex, however. Different objectives and missions tend to create barriers to effective interchanges. One of this barriers stems from the focus on knowledge's utility that each party has. For businesses, knowledge must be susceptible of commercial exploitation, whereas academy sees knowledge as a moving target that requires a methodical dedication to grasp it, with more setbacks than gains. To a large extent, these contrasting views mark the collaborative trajectory with industry playing the anxious role and university the parsimonious one (Merritt, 2004).

Clearly, confidence plays a key role in the partnership. Universities need to understand industry needs, whereas enterprises need to comprehend that scientists tend to prize more non-monetary incentives, such as academic prestige and peer recognition, than plain financial rewards. Therefore, the basic challenge for public policy in promoting university-industry collaborations is to facilitate the alignment of mutual goals and research objectives (Connell, 2005).

According to Tatiana Schofield (2013), there are three broad elements affecting potential collaboration between universities and businesses: internal, external and relational/cultural. Internal factors are related to organisational processes that can be partly controlled. External factors relate to market conditions, political, economic and legal risks, which can be mitigated though due diligence. Relational and cultural factors can ultimately enhance or inhibit the success and are critical for creating viable collaborations. She also observes that collaboration in developing countries faces additional challenges such as market stability, knowledge absorption capacity, local education, capabilities and cultural value systems, finding that cultural empathy and trust are key success factors. In order to have an idea of how contrasting goals may determine the university-industry collaboration, Figure 1 depicts their interaction.

formed in the United States is basic research, with academia having the largest share (60%). Moreover, for the past 50 years, universities have had the largest share of basic research work, with a greater increase in the last ten years because industrial basic research laboratories like Bell Laboratories and Xerox have long since shut down or scaled back, and the federal government has also cut back on intramural R&D in favour of contracts and grants to universities and companies. As a result, the amount of basic research performed in the U.S. has about doubled as a share of all R&D over the past 50 years. U.S. R&D managers now rely on academia to an even larger degree for the breakthrough innovation that will lead to next-generation products and entirely new industries.

In the case of Mexico, linkages between industry and academy are rare. Even technology research centres, which are closer to the industrial realm, experience rather thin contacts with manufacturing firms (Merritt, 2004; Merritt and Mandujano, 2011).

International organisations, such as the World Bank, have suggested that stronger technological linkages between industrial firms and universities can be obtained if the latter are forced to obtain a larger part of their operating budgets from private clients (Merritt, 2004). However, professional bonds between the business enterprise and the academic sectors in Mexico have changed very little in spite of the several institutional reforms introduced in the last fifteen years or so (Merritt and Mandujano, 2011). The following section explores the determinants of the relationship between industry and academy in Mexico.

5   University-Industry Co-operation in Mexico

Mexico is a middle-income country with a developing market economy that is closely intertwined with the much larger economy of the United States and in the last 30 years its economic development has been inconsistent. For example, the late 1980s and early 1990s saw far-reaching market-oriented structural reforms, including privatisation of hundreds of state-owned enterprises, liberalization of foreign investment laws, deregulation of the financial services sector, and across-the-board reductions in tariffs and non-tariff trade barriers. These reforms, which culminated in the ratification of the North American Free Trade Agreement (NAFTA) in 1994, attracted an influx of US$148 billion in foreign direct investment (FDI) during the next decade (Bradley, 2010). Currently, the Mexican economy is hampered by structural weaknesses that limit its potential for future growth and job creation. Mexico's workers lack specialised skills because they have less schooling than workers in advanced industrial economies (OECD, 2009).

This deficit in human capital manifests itself in stagnant labour productivity and real wages, as well through the existence of a large informal workforce. As a result, income distribution remains highly unequal because about half of Mexico's population lives in poverty. Despite a number of economic reforms, some public policies continue to hold back the economy's competitiveness and growth potential: rigid labour and commercial codes discourage hiring and inhibit informal workers from transitioning into the formal economy. Although NAFTA spurred northern and central Mexico's manufacturing centres, few new jobs have materialized for the predominantly agricultural states in the south and southwest. This uneven development pattern has failed to slow large-scale wage migration to the United States. As global competition for capital investment has increased— particularly from low-cost manufacturing in Asia—Mexico's status as a premier export hub for the North American market has eroded (Bradley, 2010).

The export model that Mexico has applied in the last 20 years relies heavily on cheap labour, and this has created a vicious cycle for exporting firms because cheap labour means low-skilled labour, which, in turn, is of little help when competition lies more on innovation capabilities than on low prices (Merritt and Mandujano, 2011).
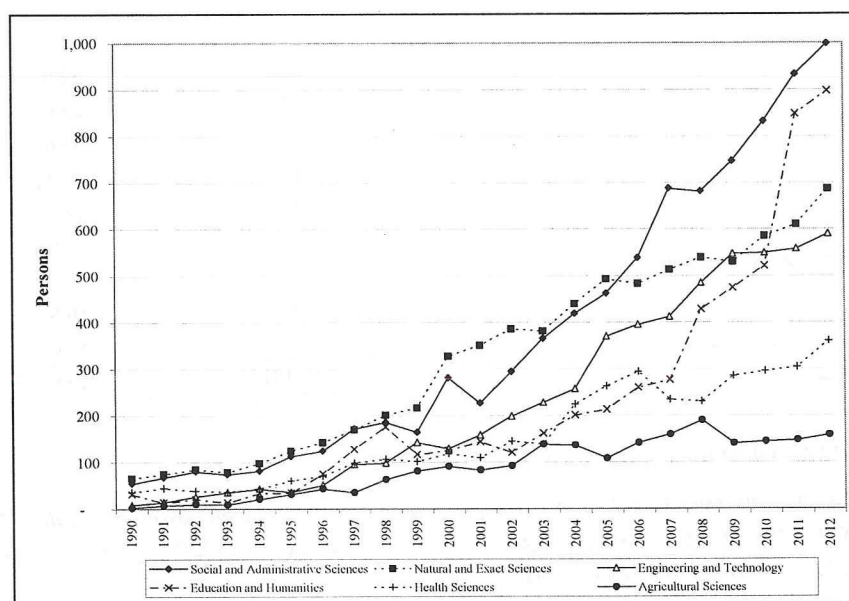
Fig.4: PhD graduates in Mexico by area of knowledge, 1990-2012

As regards the existing conditions for collaborative research between universities and small enterprises, it is worth mentioning that increasing the innovation-absorption capacity of micro, small and medium-sized enterprises (SMEs) is vital to improving productivity. Nevertheless, effective collaboration is very weak in Mexico, although universities are frequently sought by small firms to get technical services, and any potential collaboration could consider strengthening capacity-building and quality control.

The main barrier for implementing these initiatives is the lack of qualified human resources in industrial firms, however. In order to get a better idea of the actual technological capabilities that firms have, the following Table shows the structure of their staff, disaggregated by quality of labour.

Sector	R&D Personnel	(%)	Technicians	(%)	Administrative Staff	(%)	Total Personnel
Manufacturing	9,138	36.4	11,257	44.8	4,726	18.8	25,121
Services	6,796	48.4	5,659	40.3	1,597	11.4	14,052
Total	16,181	40.8	17,068	43.1	6,386	16.1	39,635

Table 3: Qualified staff in manufacturing and services in Mexico, 2009

Source: INEGI, National Survey on Industrial Research and Technological Development, available at the URL:
http://www3.inegi.org.mx/sistemas/productos/default.aspx?c=265&s=inegi&upc=702825051174&pf=Prod&ef=&f=2&cl=0&tg=0&pg=0&ct=104000000 [accessed 28 February 2014]

According to the National Survey on Industrial Research and Technological Development, the Mexican service sector has a bigger proportion of R&D personnel than the manufacturing sector, although neither of them reaches the 50 per cent mark. These figures seem to suggest that services are more likely to establish a collaborative relationship with universities. Then, a more detailed examination is needed. Table 4 shows the disaggregated figures of Table 3 but only for the R&D personnel. Thus, it is now possible to identify the most R&D intense branches in Mexico.

Sector	R&D Personnel	(as % of Total Personnel)	Total Personnel
Machinery and Equipment	4,167	35.1	11,882
Social, Personal and Communal Services	3,612	42.9	8,424
Coal, Oil, Chemicals and Plastics	2,545	49.4	5,153
Computers and Related Services	1,833	61.3	2,992
Food, Beverages and Tobacco	962	40.0	2,407
Metallic Products (Not Equipment)	864	29.6	2,914

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