SOURCES AND CONTEXTS OF INTER-INDUSTRY DIFFERENCES IN TECHNOLOGICAL OPPORTUNITIES: THE CASES OF ARGENTINA AND BRAZIL

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Abstract

It is widely accepted within the innovation and development literatures that some industries offer higher potential for growth and development than others. The general idea is that industries with high technological dynamism offer higher potential for growth and development. There is still a large element of uncertainty, however, as to which are the most dynamic industries for each country. This paper proposes to use the concept of technological opportunity (TO) to investigate the technological dynamism of manufacturing industries of two Latin American Countries (LACs): Argentina and Brazil. Our results do not support the well spread idea that traditional industries, in particular those strongly associated to Natural Resources (NRs), have and create less technological opportunities, and therefore, are less dynamic than others. They question, therefore, the adequacy of generic policies aimed at encouraging "high-tech" sectors, and suggest that context specific research needs to be conducted to identify which are the technologically dynamic industries within each country.

Key words: Innovation, Technological opportunities, Manufacturing Industries, Latin America, Traditional Industries, Natural Resources

1. Introduction

It is widely accepted nowadays within the economic, development and innovation literatures that the pattern of specialization of countries is crucially important for growth and development (ECLAC, 2007; Freeman, 1997; Hidalgo et al, 2007; Kaldor, 1967; Malerba, 2002). The general idea is that some industries offer higher potential for growth and development than others because they are more technologically dynamic. The innovation literature has developed the concept of technological opportunity (TO) to help understanding why some industries are more innovative than other. Technological opportunities are the technical possibilities open for innovation in particular industries, and they explain the easiness of innovating for any given amount of resources invested in research in each industry (Malerba and Orsenigo, p.94). Within the innovation literature, TOs are central in the explanation of why some industries innovate and are more dynamic than others. However, existing research has not made significant advances in the empirical evaluation of TOs (Klevorick et al 1995; Laursen, 1999; Malerba, 2002; Park and Lee, 2006). Only a few studies have evaluated TOs empirically, using data from a reduced number of countries and based on a limited number of indicators (such as patents, R&D). Instead, what it has become very popular and influential are certain taxonomies of industries, which, even though were not developed with the objective of measuring TOs, are often used as proxies of this concept. These taxonomies classify industries according to their technological dynamism based on R&D data from a limited number of countries (see for instance Katz and Stumpo, 2001; OECD, 2011).

This paper aims advancing understanding of the concept of TOs and of its possibilities of application in different types of contexts. To do so, we propose a methodology to evaluate technological opportunities that is consistent with the core ‘productivity-centred’ concept of TOs (as effectiveness of innovative efforts). We then apply this methodology to empirically investigate TOs and its sources in manufacturing industries of two Latin American Countries (LACs): Argentina and Brazil.

The analysis provides very interesting results. First, we found substantial variability of technological opportunities (TOs) across industries in the two countries, an important prediction of the innovation literature. Second, the industries that we identify as having high TOs in Argentina and Brazil are not those which are generally classified as having high TOs in existing empirical studies. Third, our empirical analysis does not support the well spread general idea that traditional industries, in particular those strongly associated to Natural Resources (NRs) have and create less technological opportunities, and therefore, are less dynamic than others, as it is usually derived from existing taxonomies or argued within certain literatures (Cimoli and Rovira, 2008; Hausmann, and Rigobon, 2003; Lall, 2000). Fourth, we find that only one of the three sources of TOs, identified by the literature (connections to the knowledge base, and inter and intra-industry spillovers): spillovers coming from consumers, was significant in the two LAC countries analysed.

These results provide evidence that challenge current, well settled ideas, about differences in the dynamism of industries: (i) first, that the technological dynamism of an industry is a fixed characteristic of that industry, irrespective of the context, (ii) that industry taxonomies that classify sectors according to their technological dynamism, are relevant for all countries and, (iii) that the existing sources of TO identified by the literature, based on the experience of advanced countries and suitable for firms and sectors in less advanced economies. They also provide evidence supporting the growing body of studies which suggests that the opportunities for innovation and dynamism in industries traditionally considered to be low tech or low in TOs, and in particular NRs related industries, might be increasing (Dantas et al, 2011; Lederman and Maloney, 2008; Marin et al, forthcoming; Morris, Kaplinsky and Kaplan, 2013; Perez, 2010).

The implications for policy are very important, mainly for developing countries which spend considerable amounts of resources to support the so called “high tech” industries under the assumption that these have more opportunities for innovation, growth and linkages, than the others. Our results question the adequacy of these types of policies and suggest that context specific research needs to be conducted to identify the group of sectors and linkages with more opportunities in each country.

The paper is organized as follows. In the next section we discuss the concept of technological opportunity, and the existing empirical evidence. In the third section we describe very briefly the industrial context of the countries analysed. In section 4, we present the methodology, including data sources, the variables constructed, descriptive statistics and the method used to estimate industries’ TOs and its sources. Section four presents the results and section five, the final remarks.

2. Technological Opportunities in Context

2.1 Theoretical Background

Our study is set within the context of the innovation literature. Within this literature it is almost uncontroversial the idea that, at particular times, some industries are more dynamic than others, i.e. they experience higher rates of innovation and growth than others (Cohen, 2010; Freeman, 1987; Scherer, 1965). This is reflected, it is argued, in the disparities observed across industries in the rates of patenting and R&D intensity. Two types of reasons have been proposed to explain these disparities: differences in demand and in technological opportunities.

Analysis of the role of demand have been associated mostly with the work of Schmookler (1966), who was the first to emphasize the role of market size and demand growth in determining the level of innovative activity. He offered some empirical evidence to support his ideas, however, his proposition has not survived empirical scrutiny over time. Perhaps the most persuasive refutation of Schmookler's proposition was offered by Parker (1972) and Rosenberg (1974), who documented several important historical examples[1], in which the application of a "generic" technological idea was determined not by demand but by the state of knowledge and the inherent technological complexity of the particular industry (Cohen, 2010).

Since then, based on the ideas of researchers like Parker (1972) and Rosenberg (1974) (and others that followed), the concept of Technological Opportunities (TOs) gained popularity in explaining disparities of technological dynamism among industries. Technological opportunities (TOs) are the technical possibilities for technological advance and, explain the easiness with which companies in a particular industry obtain innovations given the amount of financial resources invested (Jaffe, 1986; Laursen, 1999; Malerba, 2002). Klevorick et al. (1995) define them as "the productivity of R&D" (p.186) and suggest that they are reflected in "…the distribution of returns to R&D, given demand conditions" (p.188). Malerba (2004) suggests that TOs "reflect the likelihood of innovating for any given amount of money invested in research" (p.21) and Malerba and Orsenigo (1997) suggest similarly that they reflect "the easiness of innovating for any given amount of resources invested in research" (p.94)

According to the literature, TOs for technological advances have three sources (Klevorick et al 1995; Malerba, 2005; Park and Lee, 2006):

[1]E.g. the mechanization of hand operations in agriculture, the use of coal as an industrial fuel.

- Advances in scientific understanding, which can be a source of opportunities for innovation in two main ways (i) by increasing the problem solving capacity of professional workers and, (ii) more directly, by producing knowledge in applied sciences and engineering responding to specific problems in the industry.
- Technological advances generated outside the industry by other value chain firms (such us users and clients), which might affect innovation in other industries in many ways. For instance, advances in new materials have increased possibilities for innovation in aerospace, advances in biotechnology have improved substantially the possibilities of creating new products in the food industry, health, agriculture, among others, and,
- Feedbacks from technology, which arise if the learning used to solve a particular problem, can be used in the same industry to solve new emerging problems (Rosenberg, 1991).

The innovation literature recognizes that the importance of each one of these sources differs among technologies and industries. While for some industries opportunities for innovation are more related to major scientific breakthroughs, for others, opportunities are more related to changes in equipments and instruments (Malerba and Orsenigo, 1997). Nevertheless, a distinction is made between industries that are in general more capable to capture the benefits of the different sources of TOs and those that are less able. The first types of industries are considered to be rich in technological opportunities in all contexts; the second type, poor in TOs. Moreover, these differences in the richness of TOs are supposed to be a feature of the industry, independently of the context where this industry operates (Klevorick et al. 1995; Malerba and Orsenigo, 1997). Indeed, an important point made by this literature is that the extent and pattern of technological opportunities while different across sectors is rather invariant across countries (Malerba and Orsenigo, 1997).

2.2 Empirical Evidence

Despite the importance of the concept of technological opportunities for the innovation literature, there have not been many empirical studies addressing them. One of the first authors to evaluate TOs empirically was Scherer (1965a). He classified the different manufacturing industries on the basis of the scientific or technological field with which they were most closely associated. He then included dummies distinguishing these industries in a knowledge production function, which regressed the number of patents by industry against inventive efforts, such as R&D among other variables, holding sales constant[2]. In this way he improved substantially the explanatory power of his models, and confirmed his view about the existence of different levels of TOs across industries (evaluated as the association between inputs and outputs of the innovative efforts). He also identified some industries which were rich (e.g. organic chemicals and electronics) and poor (e.g. metallurgical industries) in TOs in the United States (US).

This study was very influential. It suffered, however, from two main limitations. First, it was based exclusively on patent data (and therefore the results were biased towards industries that had high propensity to patent) and second, it did not explored sources of TOs. Ten years later Klevorick et al (1995), using the Yale survey, offered the first cross-industry empirical examination of inter-industry differences in the sources of TOs. In their survey, they identified that buyers of materials and equipment suppliers (which they called “within the industrial chain” sources) contributed more to most industries’ technical advance than other non-industrial sources, such as universities and government labs. Their analysis also suggested that what Nelson and Winter called natural trajectories, were indeed pervasive in

[2]The initial classification scheme of Scherer distinguished chemical, electronic, mechanical, traditional industries. Then he developed other more updated classifications of industries. In Scherer 1982, he developed four broad classes: general and mechanical (G&M), electrical, chemical, and traditional. He also used three additional dummy variables to distinguish durable from nondurable goods industries, consumer from producer goods industries, and industries characterized by local or regional markets from those essentially nationwide in scope.

manufacturing technology. The relevance of science to technical advance, on the contrary, was important only for certain industries such drugs and semiconductors, agricultural sectors, and medical applications. Based on the analysis of the importance of the number and diversity of sources, thus, they suggested that industries like electronic components, aircraft and missiles, and drugs as rich in technological opportunities and; industries like stone, clay and glass, metal products and non-electrical machinery, were poor on technological opportunities.

Even though this was a very interesting and illuminating study, it focused exclusively on US Industries. Using data from Europe, Japan, and USA Malerba and Orsenigo (1997) classified industries according to technological opportunities, appropriability, cumulativeness, and the characteristics of the knowledge base. They broadly defined two types of regimes based on the ideas of Schumpeter (1912, 1942): Schumpeter Mark I, of 'creative destruction´, which was characterized by ease entry and a major role played by entrepreneurs and new firms, and, Schumpeter Mark II, of 'creative accumulation´, which was characterized by the prevalence of large established firms and the presence of important barriers to entry for new innovators. Using R&D as a proxy for technological opportunities (and other indicators appropriability, cumulativeness, and the characteristics of the knowledge base), thus, they categorised industries such as food, textiles and basic metals, as operating in a Mark II type of regime, and, industries such as organic chemicals, communications, and electronic components, as operating in a Mark I type of regime.

Since then there has been a paucity of works trying to operationalize the concept of TOs and its role across industries and countries (e.g., Geroski, 1994; Sutton, 1998)[3]. Instead, what it has become very popular and influential are certain taxonomies of industries, which are based on a reduced number of indicators and

3 Some exceptions are Laursen (1999) and Fung, (2004).

use data from a limited number of countries. The most popular of all these measures, was developed by the OECD, and distinguishes industries according to R&D intensity based on data of a handful of OECD countries (OECD, 2011) (see Table 1). Within this taxonomy, R&D intensity at the industry level is taken as a good ex-post indicator of TOs, under the assumption that firms invest more in R&D in industries where the benefits are higher.

Another taxonomy of industries that has been very influential in LACs was developed by Katz and Stumpo (2001). In this taxonomy industries are classified in three types: intensive in Machinery and Engineering; intensive en NRs and intensive in Labour. Table 1 below shows a cross reference of these two taxonomies.

Table 1 here

In sum, our review reveals that despite the importance of the concept of TO for the innovation and economic literature, only few studies have approached it empirically, and therefore there hasn't been significant advances towards its empirical evaluation. These studies share a number of problems. First, they use data from a reduced number of countries. It is common, however, that the conclusions of the research are applied, without questions, to all different kinds of contexts. Second, they have used a limited number of indicators to proxy TOs, such as R&D and patent data, which are relevant for some industries, typically the industries which are more developed in advanced countries (e.g. chemical or electrical machinery), but not necessarily for other industries. This is not consistent with what has been sustained by certain studies within the innovating literature, which have suggested that industries innovate in different ways, based on different types of efforts (Pavitt, 1984, Von Tunzelman and Acha, 2005). Third, existing studies have not clearly distinguished between efforts and results, which is not consistent with the definition of TOs and creates problems of interpretation, if the indicators used of efforts (typically R&D and patents) are not relevant for all the industries.

In the next sub-section we explain how our research addresses some of these problems.

2.3 Putting TOs in context: our contribution

We contribute to the existing research by proposing a methodology to measure technological opportunities, that is consistent with the core 'productivity-centred' concept of TOs (i.e. that aims at capturing effectiveness of innovative efforts) and, apply this methodology to explore technological opportunities and their sources in two countries that have not been considered in existing empirical studies: Argentina and Brazil.

Our aim is to link the idea of technological dynamism of industries to the specific contexts where they operate. To do so, we explore the following questions:

1) *Which are the industries with higher technological opportunities in LACs? Do they differ from the ones identified by existing empirical studies on TOs and current taxonomies?*

2) *Which are the main sources of technological opportunities across industries in LACs? Do they differ from the ones identified by existing studies based on advanced countries?*

3) *What is the role of countries' comparative advantages? Has the proximity to NRs a positive or negative effect on TOs in LACs?*

We expect that the pattern of TOs of industries in the two countries analysed differ from the pattern typically found for other countries, and additionally, that the relevance of the different sources they take advantage from differ as well. We base these hypotheses on the following ideas:

i) The scientific knowledge base and the industry structure typically co-evolve as a highly path dependent process, which depends among other things on countries' historical evolution and its factor endowments.

For example, in the 1930s the Brazilian government (President Vargas) encouraged local engineers to provide creative solutions to substitute high-cost imported components enhancing the relevance of the Technological Research Institute (IPT). This initiative was a key factor for the emergence of highly competitive industries, such as the metal industry. (Furtado, 1982 p. 23)

ii) Scientific knowledge is to some extent localized.

iii) The opportunities and capacities to generate and benefit from inter-industry spillovers depend on historical input-output relationships

iv) The opportunities and capabilities to generate and benefit from intra-industry spillovers depend on historical knowledge experience of each industry.

For example, the early specialization in agricultural production of Argentina has opened up opportunities for learning from experience and experimentation. This process increased the use of scientific and technical knowledge as a production input. In this sense, León and Losada (2002) highlight the relevance of early roots of technological developments that boosted agricultural competitiveness for grains in Argentina

Under these circumstances, we expect that TOs rather than being a fix feature of the industries, will be created in the specific contexts where industries operate, and depending on the historical evolution of the institutions and industries of these contexts. In other words, we expect that context-specific factors will create different conditions for TOs to emerge, persist and evolve.

In what follows, and before discussing in detail our methodology and the main results of our analysis, we present a brief description of the industrial context in Argentina and Brazil, which will be used to interpret our results.

3. The context: policies and industries in Argentina and Brazil

LACs have historically been and still are heavily dependent on NRs4. By the mid-20th century more than 90% of the exports of the region were related to NRs. Governments in Latin America spent part of the last century trying to reduce this dependency through the application of what were known as import substitution industrialization (ISI) policies (state-induced industrialization through subsidization of vital industries, highly protectionist trade policies, subsidized credit and the creation of an internal market). These policies managed to create a manufacturing sector in the region, with different degrees of success across countries. However, as a whole, they did not succeed in reducing substantially the dependency of the region on NRs. This went from 80% in the 1970´s to 70% in the 2000´s, and has recently been increasing (Latin America’s reliance on exports of NRs has increased by 10% over the last 15 years).

[4]By NR industries here we mean agriculture, hunting, forestry, fishing and mining. By manufacturing industries related to NRs, we mean industries that buy or sell a high proportion of their outputs to the NR industries (for instance ford products, pulp and paper products, agricultural machinery, etc.)

Argentina and Brazil have a share of NR exports which is lower than the average for LACs, but this was still very significant in 2010, right above 60%. In addition if we look at the manufacturing industries which have been developed with more success in these two countries during the last 50 years or so, we can see a bias towards sectors which are traditional, both linked and not linked to NRs. In Argentina besides the motor vehicle sector and related parts, which is heavily subsidized, the main industries which developed successfully are food processing, textiles, chemical products, petrochemicals, printing, leather, metallurgy, and iron and steel. In the case of Brazil, which is a bit more diversified, besides the motor vehicle sector which is heavily subsidized, all the other important sectors are traditional or NR related, including food, iron and steel, textiles, tobacco, and chemistry (aircrafts and associated equipment, and other machinery and equipment are also important in Brazil, but much less than the traditional and NR related manufacturing industries).

As discussed previously, traditional sectors and sectors linked to NRs, in particular those linked as consumers of NRs, such as pulp and paper, food or processing of minerals, are typically considered to have low TOs or poor technological dynamism (Cimoli and Rovira, 2008; Hausmann and Rigobon, 2003, Hirschman, 1958; OECD, 2011; Lall, 2000; McMillan and Rodrik, 2011; Prebisch, 1950; Singer, 1975) (see Table 1).There is a growing body of evidence, however, which is questioning these ideas and is pointing out to an increasing potential for innovation, dynamism, diversification and linkages in association with both traditional manufacturing sectors and NR related activities (Aman and Figuereido, 2012; Lederman and Maloney, 2008; Marin et al, 2013; Morris, Kaplinsky and Kaplan, 2013; Perez, 2010; von Tunzelman and Acha, 2005).

4. Data and Methods

This section is divided in three parts. The first describes the data sources, the second describes the construction of variables we used for our estimations and includes some descriptive statistics, the third discusses the methodology we use to estimate TOS and its sources in Argentina and Brazil.

4.1 Data Sources

For the empirical analysis we rely on information provided by the Innovation Surveys from Argentina (ENIT) and Brazil (PINTEC). Both databases are collected by official authorities, the National Statistical Council (INDEC) in the case of Argentina, and the Brazilian Institute of Geography and Statistics (IBGE) for Brazil. The first survey covers the period 1998-2001, while the second the period 2001-2003. The choice of these particular time frames responds to our priority to have contemporary periods of analysis for both countries. Two main limitations have prevented us to use more recent data: First, Input-Output (I-O) tables for Argentina are only available for 1997 (We will make use of these tables later to calculate sectors' proximities). And second, the Argentinean survey covering the years 2002-2004 is not consistent with its previous version and it does not include many variables which were necessary for the analysis.

Following the broad framework of the OSLO Manual, both Innovation Surveys make use of a wide set of quantitative and qualitative questions to evaluate numerous aspects of the economic and technological behaviour of firms. Firms are asked about relevant economic information such as their number of employees, their age, and the value of their exports, imports, and sales; along with information regarding their innovative performance and efforts, such as R&D expenditures, or the expenditures devoted to capital goods for innovation, etc.

Although the two surveys differ slightly, the information conveyed is almost identical and the specific differences have no impact on the variables we use. I-O tables can be found also at the INDEC and IBGE websites for Argentina and Brazil, respectively.

In the following section we describe in detail the construction of these variables.

4.2 Variables and Descriptive Analysis

TOs are a feature of the industry. All firms in a particular industry are supposed to receive the same stimulus from the sources of TOs that characterize that industry. For instance, technological advances generated outside the industry by other value chain firms (such as users and clients) are conditions or determinants that take place within a particular sector as a whole. Firms, however, differ in terms of their capacity to take advantage of these common sources of TOs. This 'hierarchical' nature of the phenomena analysed will be a key aspect of our empirical strategy. We, therefore, structure this subsection making a clear distinction between industry and firm level variables.

At the firm level we include the usual set of variables that have been used in the estimation of firm level determinants of innovative performance (Benavente, 2006; Chudnovsky et al, 2010; Crepon et al, 1998). Table 2 below provides a summary description:

Table 2 here

We now turn to the description of the industry level variables, the set of variables aimed at capturing the sources of technological opportunities. As previously mentioned in section 2, the innovation literature recognizes three main sources of technological opportunity (Klevorick et al 1995; Malerba, 2005; Park and Lee, 2006; Rosenberg, 1991): (a) Advances in scientific understanding, (b) Technological advances generated outside the industry by other value chain firms (such us users and clients), and (c) Feedbacks from technology.

Table 3 below describes how these industry variables were proxied. The variable named Linkages with the knowledge base aims at capturing the extent to which sectors are connected to the scientific base and, therefore, are able to take advantage of the knowledge produced by universities and think tanks (a). The variable Intra Industry Spillovers is intended to measure the extent to which innovative efforts within the same industry can be self reinforcing, generating positive feedbacks (b). Finally, to capture the extent to which technological advances/efforts generated outside the industry may be a source of TOs, we created two variables: Inter industry Spillovers from suppliers and Inter industry Spillovers from customers. These variables were calculated by adding R&D expenditures of the most proximate sectors both up and downstream in the productive chain using I-O matrices(c). We identified proximate sectors using inter-industry transactions from I-O matrices, for further details see Appendix A.

Table 3 here

Part of our analysis involves exploring the association between sectors' TOs and their proximity to NR industries. We distinguish two possible kinds of associations with NRs industries: a) manufacturing industries indirectly related to NRs as consumers, e.g. the food industry, pulp and paper and, b) manufacturing industries indirectly related to NR as suppliers, e.g. agricultural machinery, pesticides and other agro-chemical products.

We created two indexes to measure the type and extent of the proximity of different manufacturing sectors to NR industries. The first of them (1) orders all the sectors according to their proximity to NR in terms of their own purchases to NR industries while the second (2) ranks them according to their sales. The Argentinean and Brazilian I-O matrices have information about the amount of transactions between manufacturing sectors and NR industries. Taking advantage of this information we calculated the proportion of purchases from (and sales to) NR sectors made by every manufacturing industry. For every sector ***j*** on the sample, we applied the following procedure:

$$\boldsymbol{NR\ Index\ Consumers}_j = \sum_{i \in NR} (I-O)_{ij} \Big/ \sum_{i} (I-O)_{ij} \qquad (1)$$

$$\boldsymbol{NR\ Index\ Suppliers}_j = \sum_{i \in NR} \{(I-O)^T\}_{ij} \Big/ \sum_{i} \{(I-O)^T\}_{ij} \qquad (2)$$

Where NR industries include: agriculture, hunting, forestry, fishing and, mining. ***NR Index Consumers*** measures the degree of connection that manufacturing industries have as consumers of NR sectors and, ***NR Index Suppliers*** measures the connection as a supplier.

Table 4 below provides descriptive statistics of the variables. There are several regularities worth noticing. First, Brazilian firms more than double Argentinean firms in average size, both in terms of the number of employees and the amount of sales they reported. Additionally, Brazilian firms spend more resources in innovation activities in general, and in R&D activities in particular. In fact, Brazilian firms report spending 40% more in innovation expenditures as a percentage of sales than Argentinean firms (3 percentage points against 2.12). When it comes to expenditures devoted to R&D the difference is even bigger (more than 5 times bigger). However, for all the measures described above the Coefficient of Variation (CV) for Brazilian firms is higher, indicating a more heterogeneous composition of firms, with possibly a few big firms explaining much of the differences.

Argentinean firms appear to be more connected with public and private institutions as they report to be in contact with universities and think tanks twice as often as Brazilian firms (3.8% compared to 1.9%). Also other types of cooperation occur more frequently.

Regarding innovation outputs, Argentinean firms systematically report higher rates of product and processes innovations. This can be attributed mainly to two factors: first, the coverage period of the Argentinean sample is longer and, therefore, it is more likely a firm will report an innovation. And secondly, the Argentinean sample is smaller and probably contains an overrepresentation of the most dynamics firms of the economy. It is very likely that these ratios will look more similar if sample expansion factors are taken into account. For a more detailed explanation and comprehensive and useful comparison between these samples and others, see Lugones and Peirano (2004).

Industry level variables follow a similar pattern to the firm level variables. Brazilian firms show an industry average R&D expenditure that is considerably higher than the Argentinean counterpart while Argentinean sectors tend to be more connected with research institutions.

Table 4 here

4.3 Estimating TO and its Sources: Empirical Strategy

As discussed in Section 2, TOs have been typically evaluated in the existing research using two indicators, R&D intensity and patents intensity by industry. The first is a measure of efforts and the second of results, which is not relevant for all industries. Our measure of TOs for a particular industry is estimated as the coefficient of the R&D expenditure in the innovation equation, which captures the return of R&D to innovation by sector after netting out the effect of firm level determinants. In that sense, our estimation, by following closely the definition of TOs introduced by Klevorick et al (1995), Malerba (2002) and Park and Lee (2006) (i.e. the likelihood of success for any given amount of money invested in innovation) improves substantially the measures previously used.

Perhaps the greatest empirical challenge associated with the operationalization of the concept of TO as a measure of efficiency of the innovative activities is the measurement of technological advance (associated with changes in product quality, variety, and the introduction of altogether new products). Technological advance is usually measured using indicators such as patents or R&D intensity. In this paper we rely on the information provided by the innovation surveys regarding the introduction of new products and operationalization of new processes. Measures of technical advance or innovativeness based on data from innovation surveys (such as the European Community innovation studies) have become popular over the last 15 years. The most popular of these measures is based on the proportion of firms' turnover associated with the introduction of new or significantly improved products. It has been generally used as an indicator of the innovative performance of companies, industries, and countries. In principle, this is a good direct measure of innovation performance, but it discriminates against process innovation (particularly important in Argentina and Brazil). We therefore used a different approach. Following the standard distinctions in the Oslo Manual (OECD, 1997), the Argentine and Brazilian Innovation Survey asked firms about the type of product or process innovation they had introduced during the survey period, giving the firms four different possible responses: (1) they did not introduce any product (or process) innovations, (2) they introduced product (or process) innovations that were new for the company, (3) they introduced product (or process) innovations that were new for the economy, or (4) they introduced product or process innovations novel for the world economy. We consider positive responses to the last two of these options as an indicator of firm innovativeness[5].

A second important challenge is to take into account the hierarchical structure of the problem in which firm and industry level determinants interact to explain industry heterogeneity. According to Klevorick et al (1995) the determinants of TOs differ across industries and, they are responsible for generating technology gaps and above-the-average dynamism within any given sector. Therefore, along with the usual firm level determinants of innovative performance or dynamism, we must include the industry level determinants that will eventually help us to explain the presence of technological opportunities in some sectors.

We implement a random coefficient model (RCM), also called multilevel model, to econometrically deal with these issues. A RCM is a type of regression particularly appropriate for hierarchical data with relevant explanatory variables at different levels of analysis. It differs from a standard regression model in the fact that the parameters (or some of them) are given a probability model; and therefore, it contains more than one error term. A multilevel approach has two main advantages, when compared to OLS, that makes it more appropriate for this particular application: 1) it allows for the inclusion of dummies and

[5]An obvious limitation is that responses are subjective, reflecting merely the opinion of the individual responding on behalf of the firm. In particular, therefore, responses claiming to have introduced "new to the world" innovations may not reflect very precisely the occurrence of an innovation that is truly "new for the world market." However, precision in that respect is not the main issue here since we are concerned primarily with the relative innovativeness of Argentinean and Brazilian firms; and, given the possibility for respondents to select less novel kinds of innovativeness, we believe that in relative terms this category captures adequately the "more significant" end of the distribution of innovative firms.

explanatory variables at the industry level, and 2) it considers the nested structure of the data and estimates standard errors more accurately. Our primary concern is to incorporate, in a meaningful way, all these macro/industry processes, which are presumed to have an impact on the firm over and above the effects of any individual level variables.

We therefore estimate a RCM with a hierarchical structure in which the lower level of analysis is the firm. We carry on an innovation equation at the firm level and evaluate among other things the effectiveness of R&D expenditures on innovation performance[6]. We then allow the R&D coefficient to vary by sector, capturing differences of TOs across industries, and explain these differences using sources (or determinants) of TOs. As sources of TOs we include linkages with the knowledge base (***Knowledge Base***), and the potential available knowledge that could spillover from suppliers, consumers and the within the industry (***Inter industry Spillovers (Suppliers)***, ***Inter industry Spillovers (Consumers)***, and ***Intra-Industry Spillovers***, respectively).

The econometric specification (3) can be summarized as follows:

$$logit(I_{ij}) = \alpha_j + \beta_j R\&D_{ij} + \gamma Z_{ij} + \varepsilon_{ij}$$
$$\beta_j = \beta_0 + \beta_1 X_j + U_j^1$$
$$\alpha_j = \alpha_0 + U_j^0$$

With:

$$U_j^0 \sim N(0, \sigma_0^2)$$
$$U_j^1 \sim N(0, \sigma_1^2)$$
$$Cov(U_j^0, U_j^1) = \sigma_{01} \qquad (3)$$

[6]We model innovation at the firm level as it is usual in the innovation literature following the approach suggested by Crepon-Duguet-Mairesse (1998), and then used by Benavente, (2006), Lööf et al. (2001) and Chudnovsky et al (2010) among others. See Kleinknecht and Mohnen (2002) for a review of other papers that have followed this conceptual framework.

Where i indexes firms and j sectors. I_{ij} is our measure of innovation or technical advance at the firm level and follows a Bernoulli distribution that takes value 1 if the firm achieved new to the world or to the market innovation and zero otherwise, $R\&D_{ij}$ is the natural logarithm of the firm's expenditure in research and development activities, Z_{ij} is a list of firm-level control variables (as specified in Table 2 above), and X_j is a set of industry variables that we will evaluate as sources of technological opportunities (as specified in Table 3 above). The intercept α_j and the rate of return of $R\&D$ expenditures β_j are allowed to vary across sectors. Substitution leads to the model (4):

$$logit(I_{ij}) = \alpha_0 + \beta_0 R\&D_{ij} + \beta_1 R\&D_{ij} X_j + \gamma Z_{ij} + U_j^0 + R\&D_{ij} U_j^1 + \varepsilon_{ij} \quad (4)$$

What makes these sorts of models appealing for this particular application is that not only unexplained variation between firms but also unexplained variation between sectors is regarded as random. The analogous OLS model, without explicitly including industry level error terms, would have a multilevel nature only to the extent that variables differ regarding the level of aggregation. Residuals would be exchangeable after controlling by industry variables, meaning that all industry level variability is fully explained by the vector X_j. Therefore, it would be immaterial for two given firms whether they belong to the same or to different sectors given their $R\&D_{ij}, X_j, and\ Z_{ij}$ levels. $U_j^0, U_j^1, and\ \varepsilon_{ij}$ each express different parts of the unexplained variablity. All these three sources of variability can be the point of attack when trying to find sources of heterogeneity.

It is worth pointing out that multilevel models require additional assumptions compared to an standard OLS regression, in particular note that each level of the model has its own set of assumptions such as additivity, linearity, independence, and normality. Therefore, any misspecification may lead to incosistent estimates. In the analysis we conduct a series of robustness checks to address these possible problems. For more information about multilevel models please refer to Gelman (2007), de Leeuw and Meijer (2008), and Snijders and Bosker (1999).

5. Empirical Analysis

This section includes three sub-sections. First, we provide a descriptive analysis that compares the more commonly used indicator of TOs (R&D intensity), with two other descriptive measures that can be calculated with our data: a more broadly defined measure of innovative efforts (including investments in machineries and engineering) and a measure of effectiveness of R&D expenditures: the ratio of product and process innovation to R&D. Sub-sections 2 and 3 present and discuss the results we obtained with our methodology. First, we analyze the relevance of the different sources of TOs in Argentina and Brazil. Second, we provide a description of the sectors identified as having higher TOs based on our estimations of TOs and conduct a very exploratory analysis of the association between our indicator of TOs and sectors' proximity to NRs.

5.1 A first descriptive overview

Figure 1 shows the difference in R&D intensity (in black), Innovation Expenditures intensity (in grey), and in the ratio of product and process innovations to R&D across industries for Argentina and Brazil, These indexes are commonly used as a raw indicators of effectiveness. To relate our results with existing taxonomies, and also because it is clearer to visualize, the graph shows variations a two-digits industry level. Estimations in the next subsection, however, are done at three-digits level.

The Figure reveals some interesting patterns. First, there exists considerably heterogeneity across industries regarding R&D intensity, innovation expenditures and their effectiveness.

Second, while in Brazil the pattern of variation of R&D intensity is more or less consistent with the pattern predicted by the OECD classification, i.e. R&D intensity is higher in the sectors classified as ´High Tech´ by the OECD, and lower in the ´Low Tech´ ones, in the case of Argentina the pattern is not that clear. For instance, as predicted by the OECD, in Brazil sectors such as ´Computer products´ and ´Other transport equipment's´ have high R&D intensity while sectors such as ´Food products´ and ´Textiles´ have low R&D intensity.

Third, for IE intensity there is not a clear pattern of variation across industries, neither in Argentina nor in Brazil. Clearly, differences between R&D intensity and IE intensity are more significant in Argentina than in Brazil, for all industries. However, in both cases, we can find sectors with high IE intensity at the bottom, in the middle, and at the top of the OECD classification.

Finally, when we use a measure of effectiveness of the R&D (the ratio of product and processes innovations to R&D expenditures), we find a pattern which is quite different to that suggested by previous studies of TOs, and existing taxonomies. In both cases, for Argentina and Brazil, many sectors typically classified as having Low TOs or, which are ´Low or Medium-Low Tech´ within the OECD taxonomy, such as ´Food products´, ´Textiles´ and ´Chemicals´, are among the sectors with the highest rate of innovation to R&D investments. On the contrary, many of the sectors which are typically considered as having high TOs or usually denominated as ´High Tech´, such as ´Electronic equipment's´ or ´Medical instruments´ are found to have less effectiveness of R&D.

The analysis above suggests a number of things. First, industries' performance differs greatly according to the indicator used. Second, the industries that invest more in R&D as a share of their sales are not necessarily the ones with higher effectiveness of their innovative expenditures, suggesting that innovation efforts and the effectiveness of these efforts are capturing a different phenomenon. Third, some of the more effective industries in transforming innovative efforts into innovations are those linked to the traditional advantages of Argentina and Brazil, like food products.

In the next two subsections we analyse if this pattern persist when we use the multilevel analysis to estimate TOs.

Figure 1 here

5.2 TOs and its sources

Table 5 shows the results of the multilevel estimation. It presents four sets of estimations. The first two are for product and process innovation in Argentina; the last two for product and process innovation in Brazil.

The Table indicates that only the "within the industrial chain" sources of TOs are significant in Argentina and Brazil (see row 1 to 4). Indeed, we found that in these countries, only one of three sources of TOs identified by the innovation literature is significant across estimations, ***´inter-industry spillovers´*** coming from costumers. This result is consistent with previous results stating that traditional industries, and in particular those linked to NRs, innovate little based on formal learning by science and technology developed by universities. Instead, they rely mostly on practical and pragmatic ways, and use value chain firms to acquire knowledge (Pavitt, 1984; Von Tunzelman and Acha, 2005). It is also consistent with what has been recently documented by the literature about the increasing importance of the downstream stages in some branches of the food and the textiles industries, two very important sectors in Brazil and Argentina. It opens a question mark, however, about the potential relevance of other sources of technological opportunity in the case of Latin American industries.

Table 5 here

The analysis of the firm level determinants also points out some interesting insights. First the only significant determinant of innovation across countries and types of innovation is R&D expenditures. This is interesting considering that it is commonly argued that firms in developing countries rely on other types of innovative efforts, such as investment in machineries, skills, etc. Additionally, we see that in Argentina the likelihood of obtaining any type of innovation increases with the presence of cooperation agreements with labs and research institutes ***(Cooperation)*** and firm's proximity to scientific knowledge ***(Scientific Base)***. At the same time, proximity to scientific knowledge does not appear be significant neither for process nor product innovation for Brazil. Cooperation agreements only matter for product innovation. We also found that while in Argentina market share does not seem to be relevant for either product or process innovation, in Brazil this is significant in both cases. The same happens with the variable group, which measures whether or not the company is part of a conglomerate. We found a positive and significant effect of the outward orientation of the firm, measuring whether or not it serves the international market (***Exports***). In particular, for Brazil we found a positive and significant result for any type of innovation while in the case of Argentina this variable appear significant only in the case of product innovations.

Finally, size appears positive and significant in both countries for process innovation, but not for product innovation.

As it is common to any empirical work, we had to take some arbitrary decisions about the methodology and the way we constructed the variables. This in turn may have an effect on our results, in particular, two concerns are in place:

The first relates to the choice of the methodology to estimate TOs. The use of a random coefficient model to estimate technological opportunities may be seen as, and it is, one of many suitable alternatives. The possibility of explicitly modelling unexplained variation between sectors makes this methodology very appealing; however, this also imposes constraints. Each level of the model has its own set of assumptions such as additivity, linearity, independence, and normality. If the latter assumption fails, maximum likelihood estimation in a RCM may yield inconsistent estimates. The purpose of this first robustness check is to assess whether the results we obtained were influenced by this type of misspecification. We do that by estimating an analogous OLS model were the industry level variables were interacted with firm's R&D expenditures. For more information about multilevel models please refer to Gelman (2007), de Leeuw and Meijer (2008), and Snijders and Bosker (1999).

Table 6 below shows the results of this estimation. As it can be seen, there are not significative differences between estimations. The direction of the effects are exactly the same and the differences in magnitude are mostly due to differences in model specifications, i.e. logistic versus linear regression. As expected, significance in the baseline model is weaker for industry level variables as it explicitly takes into account within-sector correlations.

Table 6 here

The second relates to our choice of the variable to evaluate innovative efforts. As discussed before, R&D is a good indicator of innovative efforts for some industries but not for others. Therefore, our results regarding the importance (or the lack of such) of the different sources of TOs may be simply a reflection of the fact that R&D expenditures are not a representative portion of all the innovative efforts done by industries in LACs.

Table 7 belows reports the results of an alternative multilevel estimation in which R&D expenditures at firm level, and consecuently all the industry level variables derived from it, is replaced by innovation expenditures in general. Innovation efforts are now measured including expenditures in capital goods, equipment, hardware and software.

Results show that firm level effects found in the baseline case are almost identical under this specification. Coeffients do not differ significantly from those we obtained before. Differences are more important for industry level variables where effects become less significant. We interpret this result as an indication that innovation expenditures, by inlcuding too many different types of items, which may be more or less related to innovative activity, reduce the effect of R&D activity by increasing the variance.

Table 7 here

In the next sub-section we identifiy sectors with higher technological opportunity for Argentina and Brazil. Additionally, given the importance of NRs for these countries, we provide an exploratory analysis of the association between our indicator of TOs and proximity to NRs.

5.3 Sectors with High TOs in Argentina and Brazil: an exploratory analysis

Table 8 below shows a rank of sectors according to the value of the R&D coefficient obtained in the previous estimations. To relate our results with the existing taxonomies the table shows sectors at two-digits industry level. Results at two-digits also are clearer to visualize. In the Annex 3 we show the full list of sectors at three-digits level ranked according to their estimated TOs. The ranking was calculated taking into account both process and product innovations for both countries. We first ranked sectors according to their returns to R&D and then averaged the rankings obtained to create an index. A detailed description of industry rankings by country and type of innovation is available on the Appendix B.

Interestingly, at the top of the table we find sectors such as food processing, wood products, apparel, leather products, non-metallic mineral, and oil products. All of which are typically classified as low or medium-low tech in existing taxonomies, or as having low technological opportunity by existing studies. On the contrary, at the bottom of the table we have most of which are typically classified as ´High Tech´ industries, according to the existing taxonomies.

This is not surprising if we consider the historical importance of NR and traditional industries in the region and the recent changes in world demand and technology, which increased opportunities for innovation and dynamism in all kind of industries, included those considered as traditional (Marin et al, forthcoming; Perez, 2010; Von Tunzelman and Acha, 2005).

Consider as an example the food industry, which appears at very top in the list. This industry has been traditionally classified as low tech and dependent on suppliers of machineries for innovation. However this is changing in dramatic ways. Demand has increased the number of requirements and also has diversified them. Additionally, recent technological advancements have increased the number of areas of knowledge application with scope for innovation, not only regarding production conditions but also related to areas of sanitation, quality assurance, environmental acceptability, etc. (Von Tunzelman and Acha, 2005).

Let's consider the wine industry, an industry in which Argentina has gained competitive advantage recently. Recent changes in demand and technology have transformed this industry into a very dynamic one, with high opportunities for innovation and growth. The demand of wine has moved from valuing only price and quantity to valuing quality and variety (Artopoulos et al, 2013; Giuliani, 2007). In the wine markets nowadays "differences in taste are so valued by consumers that a vintage bottle of wine can be a luxury or positional good, as expensive as a diamond" Archibugi (2007). This shift in consumption patterns is clearly reflected in trade statistics, which show that while during the last 30 years the total volume of wine produced is declining, the total value of production in increasing (Smith, 2007).

Knowledge regarding the several mechanisms underlying wine production has also improved substantially during the last 20 years or so. These improvements have favored wine producers in two main ways. First, they opened innumerable opportunities for experimentation and development of new tastes, and second, they allowed them to reach degrees of control over the production process that were unimaginable before. For instance, advances in genetic manipulation of seeds allowed producer to design new tastes, even within the same vine variety. A similar effect has been produced by improvements in the chemistry and bacteriology fields. By improving the understanding of the fermentation process, these progresses allowed producers to have a greater predictability of wine quality (Giuliani, 2007, Smith, 2007). Additionally, developments in the ICT field have favored the process of canopy management by helping producers to take decisions with respect to intervention in the vineyard. The use of new materials in tanks has helped both the vinification and clarification processes.

Another inspiring example is the case of the Eucalyptus production in Brazil. Eucalyptus is not a native tree from the Americas but of Australia. However, South America has become the home of the largest Eucalyptus plantations in the world as well as the most productive (Figueiredo, 2009). The high productivity and quality of pulp and paper derived from Eucalyptus have made Brazil one of the world leaders in this type of product. This leadership has not been a 'natural consequence' of long term investment but the result of targeted efforts to strive for breakthrough innovations (of the world-leading type), and the support via informal (but highly responsive) links with public agencies, even across different models of policy making (by the military, by civilians, import-substitution style, 'Washington-consensus' based, etc) (Figueiredo, 2009). Before the 1960s, it was thought that good quality pulp for paper could not come from Eucalyptus, but Brazilian researchers (in-company, at universities, and technological centres) developed trees that would produce the best pulp for paper. Looking for the best seeds (sometimes imported), preparing the best hybrids and experimenting with propagation via cloning instead of traditional means, they ended up creating a genetic pool of excellence within the Eucalyptus population. In 1984, the Brazilian firm Aracruz received the prestigious Marcus Wallenberg Prize (from Sweden) after creating trees that were fungus resistant and could be propagated clonally. In 1997, Aracruz took the lead again (ahead of Canadian and Scandinavian firms) by developing and patenting a totally chlorine-free process to bleach eucalyptus pulp making it not only better for the purposes of making paper but also environmentally-friendly (Figueiredo, 2009).

Table 8 here

To conclude, we conduct a very exploratory analysis of the association between TOs and proximity to NRs. Table 9 contains correlations between sectors' indexes of proximity to NRs, calculated as described in the methodology section and: a) the ranking of R&D intensity provided by OCDE (2011) and b) our index of TOs (estimated above, as the rate of return of R&D by sector). The idea of this exercise is to relate the existence of TOs to the pattern of comparative advantages of both countries, which in this case we proxied as industries' proximity to NR sectors.

Table 9 here

This very exploratory analysis supports the idea that TOs are related to countries' patterns of comparative advantage. In both Argentina and Brazil, consumers of NRs seem to have higher technological opportunities than other type of industries, while the same holds for suppliers but only in the case of Brazil.

These results suggest the potential importance of certain mediating factors, which might increase the possibilities of some specific industries to take advantage of the sources of technological opportunity. One example could be proximity to comparative advantages, which can affect the possibilities to connect to science and educational institutions and to competitive suppliers and clients.

6. Final Remarks

It is widely accepted nowadays within the innovation literature that the pattern of specialization of countries is crucially important for growth and development. Some industries, such as semiconductors or aircraft, characterized typically as high-tech, are supposed to offer higher potential for growth than others, such as copper or footwear, characterized as low-tech sectors. This is based on the notion that these industries face higher technological and learning opportunities (or opportunities for introducing new products or process in association with investments in innovation). Despite the importance of the concept, there is paucity of work exploring technological opportunities of industries in different contexts. This is because somehow, technological opportunities are supposed to be a feature of the industry, independently of the context and, countries as heterogeneous as Bolivia, Brazil or Iran are recommended to encourage the same type of industries: the broadly defined as high-tech or dynamic.

We challenge this view based on the contention that the creation of technological opportunities is the result of a historical process that is highly localized. We explore technological opportunities using different methodologies and rich innovation data from Argentina and Brazil.

The analysis provided very interesting results. First, they confirm the idea within the innovation literature that there is strong heterogeneity between industries regarding technological opportunities. Not all industries provide the same opportunities, for innovation, it does not matter how we measure them.

Second, they show also that industries perform differently with respect to different indicators and in the two different contexts analysis. Industries with higher R&D intensity do not necessarily coincide neither with those having higher effectiveness of R&D nor higher innovation expenditures.

For Brazil, we found that traditional indicators of R&D intensity rank industries similarly, though not equal, to ranks provided by OECD and other classifications of industries. In Argentina, however, we don’t find similar pattern. What is common to the two countries is, however, a remarkable good performance of manufacturing industries related to RNs, which are traditionally considered only as sources of static comparative advantage. When we consider the indicator of effectiveness, which we consider a more adequate measure of technological opportunities, we see that industries like food products, oil, non-metallic minerals, etc. appear as high in technological opportunities and; on the contrary, industries classified as high tech in the standard industry taxonomies, such as TV and communications and electrical machineries, appear as having low technological opportunities. This is new, but it is not surprising in the context of recent discussions about the growing dynamism and innovative use of knowledge of these industries.

When it comes to evaluating the different sources of technological opportunity, we find that only one of the four sources analyzed is significant: inter-industry spillovers from costumers. All the other sources, such as linkages to the knowledge base, feedbacks within the same industry and spillovers from suppliers do not show a significant impact.

These results are exploratory, they do not provide definitive answers, but clearly and definitely raise questions about the relevance of applying existing taxonomies across different contexts and also about the sources of TOs identified by the literature.

The implications for policy are very important, mainly for developing countries which spend considerable amounts of resources to support the so called “high tech” industries under the assumption that these have more opportunities for innovation, growth and linkages, than the others. Our results questions the adequacy of these types of policies and suggest that context specific research needs to be conducted to identify group of sectors and linkages with more opportunities in each country, to encourage them instead of the broadly defined as “high-tech”.

Appendix A: Identifying consumers and supplier sectors using Input-Output tables

Using the Input-Output table containing data about inter-industry transactions within the economy, it is possible to build a matrix that for any given sector identifies the most important supplier/consumer. We did so by applying the following procedure:

For each row (sector) of the I-O Matrix (IOM), and after giving a value of zero to each element of the diagonal, we identified the maximum value of the given row and then assigned 1 to that element, and zero to any other element in that row. We have now a matrix that for each row (Sector) indentifies the most important or nearest consumer (column) by giving a value of 1 to that element, and zero to the others. Formally, we created a matrix W^c with the following characteristics:

$For\ each\ row\ i$

$$W_{ij}^{C} = 1 \quad if \quad IOM_{ij} = \max(IOM_{ij})\ and\ zero\ otherwise;$$

$additionally,$

$$W_{ij}^{C} = 0\ if\ i = j$$

Then we can calculate our object of interest, the industry variable measuring the amount of R&D spent by the most important or nearest consumer:

Inter Spillovers Con $= W^c$ ****Intra Spillovers***

An analogous procedure was taken in order to identify the most important or nearest supplier for a given sector. In that case W^s was calculated following exactly the same procedure but using IOM_{ij}^T.

Appendix B: Ranking of TOs by Country and Type of Innovation

In section 5.3 we presented a rank of sectors according to their level of TOs using industries' R&D coefficients obtained from our estimated model. The ranking was calculated taking into account both process and product innovations for both countries and after averaging R&D coefficients at three digits level to display results at two digits, in accordance with existing taxonomies. In Table B.1 below we show how this rank was constructed. We first ranked sectors according to their average returns to R&D at two-digits, and distinguishing types of innovation and countries. Later we computed the average and median rank for each sector over countries and types to create two rankings (called median and mean ranking in Table B.1). Consider sector 15, the first step involves computing the average (median) of its position for each type of innovation and for each country. After that, we obtain the average (median) level of TOs for each sector and ranked it from 1 to 22 (Median and Mean Ranking in Table B.1).

Table B.1 here

There are two aspects of Table B.1 we would like to point out. First, sectors show consistent patterns of technological opportunities across countries and types of innovation, which means that we are not losing a lot of information by taking averages. And second, there is almost no difference between the rank obtained by averaging instead of calculating the median value (Last two columns). This also points towards the robustness of these results.

Appendix C: Disaggregated ranking of sectors according to the returns to R&D (Ranking of TOs)

Table C.1 here

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Tables

Table 1: Classification of industries by technology intensity and related categories

OECD CLASSIFICATION		ECLAC CLASSIFICATION		
ISIC	**Description**	**Machinery & Engineering-intensive**	**Natural resource intensive**	**Labour intensive**
High Technology industries				
2423	Pharmaceuticals			
353	Aircraft and spacecraft			
30	Office, accounting and computing machinery			
33	Medical, precision and optical instruments			
32	Radio, TV and communication equipment			
Medium-High Technology industries				
31	Electrical machinery and apparatus, n.e.c.			
34	Machinery and equipment, n.e.c			
352+359	Railroad equipment and transport equipment			
346	Motor vehicles, trailers and semi-trailers *			
241	Basic chemicals			
242 -243	Other chemical products (excl. Pharmaceuticals)			
Medium-Low technology industries				
351	Buiding and repairing of shlips and boats			
28	fabricated metal products			
21	Paper and paper products			
26	Other non-metallic mineral products			
25	Rubber and Plasticproducts			
23	Coke, petroleum products and nuclear fuel			
27	Basic metals			
Low Technology Industries				
15-16	Food products, beverages and tobacco **			
17-18	Textiles, textile products and apparel			
19	Leather, leather products and footwear			
20	Wood and wood products			
22	Printing and publishing			
36	Furniture and manufacturing nec			

Source: Own elaboration based on OECD (2011) and Katz (2000). In ECLAC applications of this framework, the automotive industry is often identified as a distinct category in order to reflect its distinct characteristics in the Latin American context.

Table 2: Summary description of the firm-level variables considered

Variables	Description
Innovation	Dummy variable that takes the value 1 if the firm assured that it introduced, in the period of the survey, new to the world or new to the market innovations in product or processes.
Cooperation	Dummy variable that takes value 1 if the firm claimed to be engaged in joint programs of research with labs, research companies or independent consultants, and zero otherwise
Log R&D	Natural logarithm of the value of Research and Development expenditures[a]
Exports	Dummy Variable that takes value 1 if the firm reported positive exports during the period
Market Share	Firm's relative performance compared to those firms within the same sector. It is calculated as the ratio between firm's sales over industry's mean sales
Log Size	Natural logarithm of the number of employees
Group	Dummy variable that takes value 1 if the firm is part of a group or conglomerate of firms
Scientific Base	Dummy variable that takes value 1 when firms claim both, that universities or think tanks (public or private) are relevant as sources of information for innovation, and that they cooperate actively with these kinds of institutions, and 0 otherwise

Source: own elaboration.

[a]For firms who reported no R&D expenditures during that period we replaced the log of R&D by zero.

Table 3: Summary description of the industry-level variables considered

Variables	**Description**
Knowledge Base	Constructed by adding up the values of the variable Scientific Base
Intra-IndustrySpillovers	Built by adding up all R&D expenditures within each sector.
Inter industry Spillovers (from suppliers and Clients)	Built applying the following procedure: For every sector in the sample we identified which sector was the most important supplier/consumer using I-O matrices, then we added up the R&D expenditures of that sector. Therefore we measure the amount of R&D expenditures of neighboring sectors (in terms of the productive chain).

Source: own elaboration

Table 4: Descriptive statistics of the variables included in the analysis

	Argentina				Brazil			
	Min	**Max**	**Mean**	**CV**	**Min**	**Max**	**Mean**	**CV**
Industry level Variables								
NR Index (Consumers)	0	0.915	0.127		0	0.801	0.124	
NR Index (Suppliers)	0	0.817	0.168		0	0.907	0.092	
Knowledge Base	0	8	1.123		0	7	0.921	
R&D Expenditures	0	0.48	0.14		0	1.03	0.74	
Firms.Doing R&D	0	45	6.86		0	76	17.10	
Firm level Variables								
Sales	0	4398	37.87	4.31	0	49051	80.97	9.57
Exports	0	1	0.461	1.08	0	1	0.46	1.08
Employees	0	10865	211.1	2.51	10	34520	435.7	3
InnovationExpenditures	0	2.65	2.12	6.02	0	1.5	3	7.94
R&D Expenditures	0	0.29	0.13	7.55	0	0.8	0.74	14.7
Scientific Base	0	1	0.038	5	0	1	0.019	7.1
Cooperation	0	1	0.41	1.2	0	1	0.054	4.17
Group	0	1	0.226	1.85	0	1	0.139	1.3
Product Innovation (W)	0	1	0.115	2.77	0	1	0.013	8.66
Process Innovation (W)	0	1	0.057	4.07	0	1	0.007	12
Product Innovation (M)	0	1	0.346	1.38	0	1	0.094	3.1
Process Innovation (M)	0	1	0.18	2.14	0	1	0.056	4.1

Sales, Exports, Employees, and Expenditures values correspond to years 1998 and 2001 for Argentina and Brazil, respectively. All other variables cover the whole sampled period. Sales are expressed in millions of dollars at current prices. R&D and Innovation Expenditures are displayed as a ratio w.r.t. sales and in percentages. (W) and (M) stand for New to the World and New to the Market innovations, respectively. Number of Firms: Argentina 1667, Brazil 4787. Number of Sectors: Argentina 57, Brazil 101.

Source: own elaboration

Table 5: Results of the Multilevel Analysis

		Argentina		Brazil	
	Variables	**Product Innovation**	**Process Innovation**	**Product Innovation**	**Process Innovation**
IndustryLevel	***Inter Spillovers (Suppliers)***	0,009 (0,054)	-0,054 (0,067)	-0,036 (0,036)	-0,006 (0,049)
	Inter Spillovers (Consumers)	0,116 ** (0,052)	0,126 ** (0,055)	0,013 (0,065)	0,196 ** (0,08)
	Scientific Base	-0,005 (0,056)	-0,014 (0,075)	0,032 (0,039)	-0,066 (0,055)
	IntraIndustry Spillovers	-0,035 (0,057)	0,058 (0,087)	0,037 (0,069)	-0,008 (0,079)
FirmLevel	***(Intercept)***	-2,33 *** (0,189)	-3,457 *** (0,248)	-3,913 *** (0,265)	-7,748 *** (0,427)
	Cooperation	0,708 *** (0,128)	0,579 *** (0,153)	0,674 *** (0,198)	0,143 (0,241)
	Market share	0,225 (1,294)	1,718 (1,251)	1,239 * (0,666)	2,643 *** (0,742)
	Log Size	0,068 (0,043)	0,18 *** (0,055)	-0,018 (0,051)	0,5 *** (0,073)
	Scientific Base	0,375 *** (0,053)	0,279 *** (0,06)	-0,257 (0,298)	0,296 (0,351)
	Exports	0,359 *** (0,133)	0,238 (0,157)	0,493 *** (0,145)	0,677 *** (0,218)
	Group	0,118 (0,145)	0,108 (0,161)	0,333 ** (0,137)	0,538 *** (0,16)
	R&D	0,123 *** (0,019)	0,048 ** (0,022)	0,283 *** (0,032)	0,167 *** (0,039)

Significance Codes: 0 '***' 0.001 '**' 0.01 '*' 0.05
Source: own elaboration.

Table 6: Results (OLS Regression)

		Argentina		Brazil	
	Variables	**Product Innovation**	**Process Innovation**	**Product Innovation**	**Process Innovation**
IndustryLevel	***Inter Spillovers (Suppliers)***	0,004 (0,008)	-0,012 (0,007)	-0,005 (0,008)	0,002 (0,003)
	Inter Spillovers (Consumers)	0,018 *** (0,004)	0,025*** (0,005)	0,001 (0,008)	0,023 * (0,011)
	Scientific Base	-0,002 (0,009)	0.000 (0,02)	0,005 (0,007)	-0,005 (0,004)
	IntraIndustry Spillovers	-0,003 (0,009)	0,005 (0,019)	0,012 (0,010)	0,012 * (0,005)
FirmLevel	***(Intercept)***	0.062 ** (0,021)	-0,023 (0,02)	-0.02 (0,02)	-0.119 *** (0,019)
	Cooperation	0,132 *** (0,033)	0,078** (0,029)	0,151 *** (0,04)	0,06 (0,03)
	Market share	0,011 (0.11)	0.22 (0.136)	0.285 ** (0,095)	0,558 *** (0,105)
	Log Size	0,008 (0,007)	0,016 ** (0,06)	-0,001 (0,004)	0,016*** (0,004)
	Scientific Base	0,072 *** (0,009)	0,279 *** (0,06)	-0,065 (0,071)	0,012 (0,05)
	Exports	0,065 ** (0,023)	0,03 (0,018)	0,029* (0,011)	0,008 (0,006)
	Group	0,023 (0,027)	0,018 (0,028)	0,038 ** (0,014)	0,04 *** (0,013)
	R&D	0,026 *** (0,003)	0,009 * (0,004)	0,025 *** (0,002)	0,008 ** (0,003)

Standard errors are clustered by industry using a Heteroskedasticity robust estimation of the covariance matrix.
Significance Codes: 0 '***' 0.001 '**' 0.01 '*' 0.05
Source: own elaboration.

Table 7: Results of the Multilevel Analysis using Innovation Expenditures

		Argentina		Brazil	
	Variables	**Product Innovation**	**Process Innovation**	**Product Innovation**	**Process Innovation**
IndustryLevel	***Inter Spillovers (Suppliers)***	-0,005 (0,019)	-0,032 (0,020)	0,033 (0,036)	0,02 (0,051)
	Inter Spillovers (Consumers)	0,004 (0,022)	0,029 (0,022)	0,048 (0,033)	0,101 * (0,043)
	Scientific Base	-0,034 (0,028)	-0,003 (0,028)	0,034 (0,038)	-0,045 (0,054)
	IntraIndustry Spillovers	0,043 (0,032)	0,005 (0,032)	0,084 (0,06)	-0,005 (0,083)
FirmLevel	***(Intercept)***	-2,35 *** (0,197)	-3,587 *** (0,271)	-4.549 *** (0,268)	-8.549 *** (0,470)
	Cooperation	0,678 *** (0,126)	0,501*** (0,152)	0,949 *** (0,194)	0,283 (0,24)
	Market share	0,269 (0.681)	0,796 (0.690)	1,844 ** (0,642)	2,759 *** (0,773)
	Log Size	0,042 (0,044)	0,119 * (0,056)	0,084 (0,053)	0,48 *** (0,077)
	Scientific Base	0,364 *** (0,053)	0,234 *** (0,061)	-0,178 (0,293)	0,301 (0,352)
	Exports	0,341 *** (0,131)	0,178 (0,158)	0,675 *** (0,141)	0,686 ** (0,217)
	Group	-0,028 (0,142)	0,011 (0,161)	0,377 ** (0,134)	0,523 ** (0,161)
	Innovation Expenditures	0,084 *** (0,019)	0,101 ** (0,022)	0,094 ** (0,036)	0,191 *** (0,054)

Significance Codes: 0 '***' 0.001 '**' 0.01 '*' 0.05
Source: own elaboration.

Table 8: Ranking of Sectors by Level of TOs

Sector	Description
	High TOs
15	FoodProcessing
20	Wood products
26	Non metalic minerals
18	Apparel
23	Oil products
19	Leather products
17	Textiles
	Medium TOs
33	Medical instruments
22	Printing
27	Basic metals
28	Metal products
24	Chemicals
16	Tobacco
29	Machineries
30	Office equipments
	Medium TOs
21	Paper[b]
35	Others transport
36	Furnitures and others
32	TV and communications
31	Electrical machineries
25	Rubber
34	Automotive

The ranking was calculated taking into account both process and product innovations for both countries. For further details see the appendix

Source: own elaboration.

[b]Please note the paper industry appears among the industries with lower technological opportunities here due to two problems: 1) Brazil, as described in the text a country leader in this industry, has not his strongest capabilities in the manufacturing part of the process, but in the forestry stage, where the country has made significant innovations and 2) there is problem of aggregation, in Appendix B, where we present TOs per industry at three digits level, “Paper and paperboard for packaging” appears 8th in the rank of industries with the highest TOs, out of 110 industries. The

high competitiveness of the forestry industry in Brazil explains also why wood products appears top in the list in Table 8 (see explanation below)

Table 9: Correlation between TOs and NRs

	Ranking from TOs	OECD Ranking
Argentina		
NR Index (Supplier)	-0.2	0.49
NR Index (Consumer)	0.45	-0.39
Brazil		
NR Index (Supplier)	0.34	-0.17
NR index (Consumer)	0.42	-0.39

Source: Own elaboration. The OCDE Ranking was obtained from OCDE (2011).

Table B.1: Ranking of Sectors by Level of TOs

	Brazil		Argentina					
Sector	Process	Product	Process	Product	Median Ranking	Mean Ranking	Level of TOs (Median)	Level of TOs (Mean)
15	3	4	8	3	3	1	High TOs	High TOs
16	10	15	21	4	13	13	Medium TOs	Medium TOs
17	14	5	4	15	7	7	High TOs	High TOs
18	1	2	22	2	1	4	High TOs	High TOs
19	5	3	15	9	5	6	High TOs	High TOs
20	4	1	17	1	2	2	High TOs	High TOs
21	9	16	14	21	17	16	Low TOs	Low TOs
22	20	7	1	13	8	9	Medium TOs	Medium TOs
23	2	17	7	5	4	5	High TOs	High TOs
24	12	13	11	12	12	12	Medium TOs	Medium TOs
25	22	14	18	17	19	21	Low TOs	Low TOs
26	8	6	3	8	5	3	High TOs	High TOs
27	13	10	13	6	11	10	Medium TOs	Medium TOs
28	15	11	9	7	8	10	Medium TOs	Medium TOs
29	6	20	6	22	14	14	Medium TOs	Medium TOs
30	18	22	5	11	16	15	Low TOs	Medium TOs
31	19	19	16	14	19	19	Low TOs	Low TOs
32	17	18	20	19	22	22	Low TOs	Low TOs
33	11	9	2	18	8	8	Medium TOs	Medium TOs
34	23	21	10	20	23	22	Low TOs	Low TOs
35	16	23	12	10	15	17	Medium TOs	Low TOs
36	21	12	19	16	19	19	Low TOs	Low TOs
37	7	8	23	23	18	17	Low TOs	Low TOs

Source: Own elaboration. Ranks are obtained using estimated industry coefficients.

Table C.1: Ranking of Sectors by Level of TOs at three digits

		Brazil		Argentina	
Sector	**Description**	**Process**	**Product**	**Process**	**Product**
151	Animal production	55	57	52	53
152	Fruits and vegetables	63	96	41	17
153	Vegetable and animal oils and fats	85	91	13	46
154	Dairy products	97	98	1	18
155	Grain mill products, starches	64	92	48	20
156	Sugar and sugar confectionery	101	82		
157	Coffee	69	77		
158	Other Food Products	95	48		
159	Beverages	54	93		
160	Tobacco products	41	39	9	42
171	Textile fibres	59	68	35	10
172	Spinning of textile fibres	94	86	49	9
173	Weaving of textiles	35	72	31	44
174	Made-up textile articles	22	54		
175	Finishing of textiles	61	78		
176	Other textiles except apparel	6	89		
177	Knitted and crocheted fabrics	25	63		
181	Wearing apparel, except fur apparel	100	100	6	47
182	Apparel accessories and work wear	73	38		
191	Tanning and dressing of leather	82	88	25	24
192	Luggage, handbags, other leather products	78	83	21	41
193	Footwear	89	94		
201	Sawmilling and planning of wood	96	97	19	49
202	Products of wood, cork	65	81	17	43
211	Pulp	72	29		
212	Paper and paperboard	58	32		
213	Paper and paperboard for packaging	92	85		
214	Other articles of paper and paperboard	9	27		
221	Printing and services	10	80	42	30
222	Pre-press and pre-media services	29	61	53	15
223	Reproduction of recorded media	49	73	29	27
232	Refined petroleum products	71	22	40	48
234	Alcohol	93	55		
241	Basic chemicals, fertilisers, nitrogen	38	51	20	51
242	Agrochemical products	36	14	38	6

243	Resin and elastomers	79	35	33	22
244	Man made fibers	8	76		
245	Basic pharmaceutical products	28	20		
246	Pesticides	39	46		
247	Soap and detergents, perfumes	98	84		
248	Paints, varnishes printing ink	23	99		
249	Other chemical products	83	9		
251	Rubber products	4	69	4	52
252	Plastics products	47	31	27	3
261	Glass and glass products	86	79	46	34
262	Cement	52	40		
263	Articles of concrete, cement and plaster	31	53		
264	Other porcelain and ceramic products	91	95		
269	Stone, lime and non-metallic mineral prod	33	67	37	39
271	Basic iron and of ferro-alloys	68	74	8	50
272	Basic products of steel	19	28	47	29
273	Tubes, pipes, hollow profiles	40	33	11	31
274	Basic precious and other non-ferrous metals	26	66		
275	Casting of metals	81	87		
281	Structural metal products	88	17	30	40
282	Tanks, reservoirs and containers of metal	43	13		
283	Forging, pressing, stamping of metal	7	71		
284	Cutlery, tools and general hardware	51	43		
289	Other fabricated metal products	14	101	39	36
291	Engines and turbines except for aircraft	99	6	51	5
292	Other general-purpose machinery	20	44	15	2
293	Agricultural and forestry machinery	87	3	12	1
294	Metal forming machinery tools	18	49		
295	Machinery for mining and construction	77	23		
296	Other special-purpose machinery	67	7		
297	Weapons and ammunition	80	37		
298	Domestic appliances	90	58		
299	Repair Industrial Machinery	70	16		
301	Office machinery and equipment	45	70		
302	Computers and peripheral equipment	15	2		
311	Electric motors, generators, transformers	84	34	18	33
312	Electricity distribution and control	5	10	7	7
313	Wiring and wiring devices	75	36	10	25
314	Batteries and accumulators	62	26	28	32
315	Electric lighting equipment	37	24	43	28
316	Electric material for vehicles	13	18		
318	Repairing of electric machinery	11	56		
319	Other electrical equipment	21	19	16	13

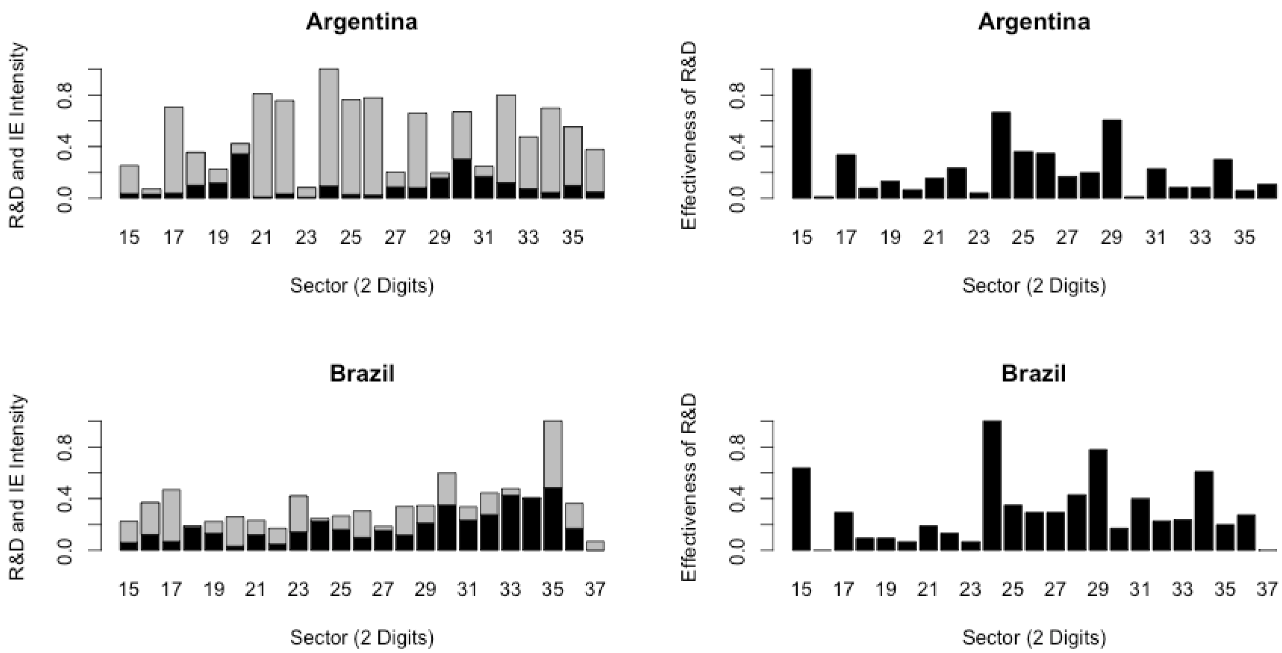
321	Electronic components and boards	76	75	14	12
322	Telephone equipment, radio and TV	42	11	5	35
323	Communication equipment	2	15	24	8
329	Repairing communication equipment	48	59		
331	Medical equipment	56	90	50	16
332	Instruments measuring, testing and navigation	57	42	22	21
333	Industrial process control equipment	53	41		
334	Optical medical and photographic equipment	50	45		
335	Watches and clocks	16	64		
339	Repairing optical instruments	46	52		
341	Motor vehicles	3	12	2	14
342	Commercial vehicles, buses, coaches	32	8	44	4
343	Bodies for motor vehicles	74	30	45	37
344	Parts for motor vehicles and their engines	1	5		
345	Repairing motor vehicle, engines	12	25		
351	Construction, repairing ships and boats	24	1	23	38
352	Construction, repairing locomotives, railroad cars	66	65	26	45
353	Construction and aircraft repairing	30	4	34	26
359	Other transport equipment	27	21	32	19
361	Furniture	34	47	3	11
369	Other manufacturing	17	50	36	23
371	Recycling of metal waste and scrap	60	62		
372	Recycling of non-metal waste and scrap	44	60		

Source: Own elaboration. Ranks are obtained using estimated industry coefficients.

Figures

Figure 1: R&D and IE patterns

Graphs on the left hand side display R&D and IE intensity (R&D over sales and IE over sales, respectively). R&D expenditures are a share of all innovation expenditures and are showed in black. On the right hand side only R&D effectiveness is shown, as IE effectiveness show an almost identical pattern. IE includes R&D expenditures, but investments in machineries, royalties and IT equipment



15 Food products and beverages
16 Tobacco products
17 Textiles
18 Wearing apparel
19 Leather and related products
20 Wood and of products of wood and cork
21 Paper products
22 Printing and reproduction of recorded media
23 Coke and refined petroleum products, nuclear fuel and alcohol
24 Chemical products
25 Rubber and plastic products
26 Non-metallic mineral products
27 Basic metals
28 Fabricated metal products
29 Machinery and equipment
30 Computer products
31 Electrical equipment
32 Electronic products and communication equipment
33 Medical, precision and optical instruments
34 Motor vehicles, trailers and semi-trailers
35 Other transport equipment
36 Furniture and other manufacturing
37 Recycling