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## « Innovation and Development. The Evidence from Innovation Surveys »

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# Innovation and Development.
# The Evidence from Innovation Surveys.

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***Abstract***

In this article we investigate the existing evidence on innovation produced by innovation surveys in developing and emerging countries in Europe, Asia, Africa and Latin America. We review the relevant literature, discuss methodological issues, and analyse the results for the countries with the most comparable surveys, considering the well established findings of innovation surveys for Europe as a benchmark. From the evidence we considered, regional patterns are identified and some stylized facts on innovation and development are proposed, pointing out the specificity of innovation processes in economies engaged in industrialisation and catching-up.

***Keywords:*** *Innovation Surveys, Patterns of Innovation, Emerging Countries*

***JEL Classification:*** *O14, O19, O3, O54*

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## 1. Introduction

Innovation is receiving increasing attention in the development debate. Far from being a concern of advanced countries alone, the ability to introduce new technologies and organisations is now seen in developing economies as a crucial element in the process of industrialisation and modernisation. Major efforts to introduce new products and processes, to imitate rapidly frontier innovators, to widely adopt new capital equipment and production technologies, to diffuse the use of new goods and services are now under way in many developing and emerging economies, from Eastern Europe to China, from India to Latin America, from Mediterranean countries to Southern Africa (for brevity's sake, we will refer to them as *Developing Countries*[2]). This process is highlighted by the success of some Asian countries (most recently China and India) in shifting from a paradigm of technology adoption to one of domestic knowledge generation (Chadha, 2009; Altenburg et al. 2008; OECD, 2007), although the ability of other countries to follow the same road has been questioned (Sargent and Matthews, 2008; Perez, 2008[3]). Such attention has led to a rapid diffusion in these countries of innovation surveys, replicating and adapting the model first developed in Europe (Eurostat, 2008). The advantage of innovation surveys is in their ability to document the complex and multi-dimensional nature of technological change in firms (Dosi, 1988; Pavitt, 1984), offering a variety of indicators on inputs, outputs, sources, objectives and hampering factors.

The aim of this article is twofold. First, we systematically review the evidence now available on innovation in Developing Countries, discussing methodological issues and comparing results; second, we propose an interpretation of the emerging patterns of technological change - in relation also to the experience of Europe - and identify different technological strategies that shape and constrain the development process. These insights may contribute to a more effective design of policies, both at the national level, with more appropriate innovation and industrial policies[4], and at the international level, with regards to the governance of knowledge and technology flows, including the rules on Intellectual Property Rights.[5]

The relationship between technological change and the process of development has been investigated by a variety of approaches, from the historical perspective of Abramovitz (1986) to the neoclassical framework of Keller (2004), from the industrialization-focussed theory by Lall (1992) to the Evolutionary and Neo-Schumpeterian theories by Freeman and Louça (2001), Perez (2002) and Nelson (2006), ending with the Global Value Chain Approach (for a review see Morrison et al., 2006). Although they have major differences, there is an underlying consensus that the origin of the development process is rooted in the growth of productivity, and not in a simple factor accumulation process; technological change is recognised unanimously as the main force enhancing

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[2] Some of the European and Asian countries we will consider are *developed* economies. However, our evidence includes the Nineties, when industrialisation and international integration accelerated, and is illustrative of the role of innovation in successful development strategies.

[3] Perez (2008) argues that in the established techno-economic paradigm this shift is impossible without a specific development strategy, coordinated by the government.

[4] The positive role that innovation surveys can play in a better design of policies is stressed by Mairesse and Mohnen (2008), especially with reference to the existence of policy complementarities. Fagerberg and Srholec (2009) carried out a comprehensive analysis of innovative patterns, showing that policies tailored to the attraction of high tech activities can be an appropriate strategy only when coupled with a strengthening of the quality of the environment (capacity to mobilize the proper factors, reliability of the social and institutional structure, capability to move from idea to innovation). Cimoli, Dosi and Stiglitz (2009) link policies for technological change, accumulation of capabilities and development.

[5] A growing debate is addressing the global governance of technology flows; although some of the reforms of the 1990s have been recognized as productivity enhancing (Figuereido, 2008; Lopez, 2008; Dijofack-Zebaze and Keck, 2009), there is a widespread concern that the actual regime of Intellectual Property Rights Protection is too strong (Chang, 2001; Falvey et al., 2006, Bogliacino and Naranjo, 2008; Stiglitz, 2008); new avenues could be opened in terms of South-South cooperation (Perez, 1994), while new conflicts may emerge with the rise of new actors such as China (Gu et al. 2008).

productivity growth (OECD, 2007). However, most studies have so far looked at technology in a rather undifferentiated way, using indicators - such as R&D and patents - that are inappropriate for Developing Countries (and limited for the developed ones as well, see Archibugi and Pianta, 1996; Smith, 2005). A major contribution of innovation surveys investigated in this article is their ability to show the diversity of innovative activities and the alternative directions that efforts at improving technologies and organisations may take, with diverging effects on the development process. In order to identify these patterns, we will investigate the main typologies of innovation (new products and processes), the sources and hampering factors, the expenditures and outputs - including the share of innovative turnover - and the strategies pursued by innovative activities.

Moreover, this article integrates the evidence provided by efforts to build internationally comparable measures of technological capabilities using traditional indicators of scientific activities, R&D, patenting, etc. International organizations have addressed this challenge from different perspectives (see World Bank, 1999; UNDP, 2001; UNIDO, 2003) and several studies have been produced by scholars (Amsden and Mourshed, 1997; Bell and Pavitt, 1997) and business sources (for a review see Archibugi et al. 2009). A systematic comparison on different dimensions, leading to a synthetic composite indicator has been carried out by Archibugi and Coco (2004). The richness of comparable results from innovation surveys can now complement the limitations of technology indicators relying on traditional indicators.

The article proceeds as follows: Section 2 discusses the diffusion of innovation surveys; Section 3 critically reviews the results and the methodological issues; Section 4 shows the results on a subset of major countries; Section 5 presents a set of stylized facts on innovation and development.

## 2. The diffusion of innovation surveys

Europe has pioneered the surveys on innovation in firms, developing a common methodology, described in the Oslo Manual[6] (OECD, 2006), and four comparable waves of the surveys have now been carried out (for the most recent results of the third survey, see Eurostat, 2008). The EU practice has progressively extended to other countries and represents the current international standard for the methodology of innovation surveys; the Oslo Manual has been used in the Central and Eastern European Countries of New Accession to the EU (EU-NAC), in the candidate countries to European membership (Radosevic, 2004), and has provided the guidelines for all other surveys.

In Eastern Europe and the Balkans, the EU model of innovation surveys has been adopted by Russia, Ukraine, Macedonia, Croatia and Turkey. In the first two countries the evidence shows that after the end of the Soviet Union a drastic reduction of technological and scientific activities took place, followed by a modest rise in recent years. A detailed picture on Russia can be found in EU-Russia cooperation program (2007), and firm level data have been object of analysis by Roud (2008); for the case of Ukraine, empirical data and policies have been assessed in Yegorov (2008).

Turkey has followed a methodology comparable to the European one and provides scholars with a significant amount of data (Meschi et al. 2008); several strands of literature have emerged, including studies on the relations between openness, innovation and market outcomes, and on the impact on the quantity and skill composition of employment.

Outside Europe, a major effort has been carried out in Latin America. After a first generation of innovation surveys conducted on pilot samples, countries moved towards a standardization, which culminated into the Manual de Bogotá (2001): grounded on the Oslo Manual, its main aim was the design of a survey tailored for Developing Countries. Three waves of

[6] The Oslo Manual was the result of a joint effort of the European Union and the OECD. Developed Countries with surveys comparable to the Community Innovation Surveys (CIS) include EU member countries, Norway, Iceland, Switzerland, Canada, Australia, New Zealand, Turkey and Japan. The United States has only recently planned an innovation survey, with its own methodology.

innovation surveys in different Latin American countries have been conducted.

The first innovation surveys took place in 1995-1997 in five countries (Argentina, Colombia, Chile, Mexico and Venezuela), with results that are not comparable in any of the relevant dimensions (Sutz, 2000). A second wave of surveys has been conducted in eight countries (Argentina, Brazil, Uruguay, Chile, Mexico, Cuba, Ecuador, Panama, Peru, Trinidad and Tobago). Finally, in recent years two other surveys have been undertaken in Brazil and Colombia, another one in Chile, Uruguay and Argentina.

The objective of the Bogotá Manual was to adapt the Oslo Manual to a region with a different environment in terms of innovation systems, average firm size, integration among key actors, location of relevant markets. The Oslo Manual is considered too much focused on frontier technologies and original innovations. Compared to Europe, the typical Latin American economy carries out less R&D, has a more complex set of strategies for acquiring, adaptating and improving technologies, and has weak interactions among firms and institutions involved in innovation. There is a consensus among Latin American scholars that the main determinant of this lagging behind is the lack of basic capabilities to exploit advanced technologies (Lugones, 2006; Salazar and Holbrook, 2004).

This far-from-the-frontier innovative activity can be better described by addressing the role played by different objectives and hindering factors (especially with regards to small and medium firms), by paying more attention to the experiences of "failure", and by systematically investigating the imitation activities that sometimes represent a continuous incremental change of capabilities with significant effects on productivity (see Dosi, 1988 for a theoretical discussion, and Salazar and Holbrook, 2004, for specific issues). As a consequence, the Bogotá Manual is more *activity-related* than centered on the innovative firm; there is space to register intermediate innovative efforts, adaptation of technologies, organizational changes, marketing efforts, quality management (Salazar and Holbrook, 2004).

Few studies have discussed the results in a comparative perspective (Turriago, 2003, on Argentina, Chile, Colombia and Venezuela; Hall e Maffioli, 2008, on Argentina, Brasile, Chile e Panama; Raffo et al., 2008, for a comparison with Europe). The main part of this literature is limited to either one country or a specific industry. Brazil, Chile and Colombia are the most studied, and the most important contributions include De Negri et al. (2007) and Langeback and Vasquez (2007) on the relation between inputs and outputs of the innovative process; the relation between innovation and productivity has been investigated by Goedhuys (2007) and Benavente (2006) – using the Crepon, Duguet and Mairesse (1998) approach; the labour market effect of innovation is investigated by Benavente and Lauterbach (2008); an overall discussion over Latin America is in Cassiolato et al. (2003).

Important efforts at surveying innovation have also been carried out in Asia. China has a long experience in measuring innovation performances; the last survey, covering the years 2004-2006, is comparable to EU standards and has a large sample size, even among small firms. This impulse to data gathering comes from the desire to monitor the relevant changes in the Chinese innovative system in terms of actors and institutions. This statistical evidence has been elaborated in a large literature, focused on the sources of knowledge, regional disparities, and the impact on the growth potential (DeBresson et al. 2006; Alcorta et al. 2008).

In East and South East Asia a number of countries have carried out innovation surveys similar to the European ones. A rich strand of literature has developed on the cases of South Korea (Oh et al., 2007), Taiwan (Hsien-Ta Wang et al., 2003), Thailand (Intarakumnerd et al. 2002), while some studies exist on Singapore, Malaysia and other countries..

In Africa, innovation surveys have been conducted in Morocco, South Africa, Tanzania, and Tunisia with a limited success when compared with international standards (Blankley and Kaplan, 2006). More general studies on African development stressed the role played by the lack of resources and the inability to absorb external knowledge as hindering factors (Lall and Pietrobelli, 2002).

All these contributions provide a significant improvement in the documentation and

understanding of the variety and complexity of technological activities carried out in Developing Countries; results and methodologies for specific countries are addressed in detail in the next section.

## 3. Methodological issues and overview of the evidence

In order to examine the empirical evidence on innovation in Developing Countries we have to assess the reliability, significance and comparability of results. The debate over the measurement of innovation has grown substantially in the last two decades and the efforts of statistical institutes and international organisations have provided a major base for obtaining high quality information on innovation in firms (for reviews, see Archibugi and Pianta, 1996; Smith, 2005; Mairesse and Mohnen, 2008).

In this Section we review the methodology and the quality of the available data for Developing Countries (see also Blankley et al. 2006). Two problems tend to emerge in different experiences; first, the specificity of the innovation processes and institutional settings of Developing Countries has led to a primary focus on the domestic generation of knowledge and capabilities; the distance from the frontier is often so large that countries and firms lack a critical mass of knowledge needed to exploit externally generated knowledge. As a consequence, in Latin America the regional Manual has devoted more attention to a better measurement of training activities, technology acquisition and organizational innovations (Lugones, 2006; Anlló, 2006). The second problem concerns sample design, and the main shortcoming is often the bias towards large firms: the lack of significant coverage of small firms - that in Developing Countries represent the largest part of industry and services - prevents an understanding of the actual process of knowledge generation and diffusion.

We will now present an overview of the different regions in order to identify a subset of comparable countries for which we can investigate the results of innovation surveys.

### *3.1 Central and Eastern Europe and Russia.*

Central and Eastern European countries which carried out innovation survey include new members of the European Union (Bulgaria, Czech Republic, Latvia, Estonia, Lithuania, Hungary, Poland, Slovenia, Slovakia, Romania), candidate countries such as Croatia, Turkey and finally Ukraine and Russia. For these countries the problems of modernisation overlapped with those of transition to market economies and a key question concerned the role of innovation in the transformation of the economic system and integration in Europe and in international markets.

The international supervision of policies for the transition was inspired by the mainstream recipes typical of the "Washington consensus"; such approach argued that macroeconomic stabilization, trade liberalization and privatization of state firms would stimulate efforts to innovate; openness and FDIs would function as channels of transmission of knowledge, while privatization and competition would serve as sufficient pressures to build networks of new entrepreneurs able to compete on international markets through more efficient organization and an orientation towards product innovation.

After the dramatic fall in economic activity of the early 1990s, in the last decade a strong economic performance – with high growth rates of per capita GDP – has led to a moderate convergence towards EU average incomes. However, an analysis of innovation data (Radosevic, 1999, 2006) raises some doubts over the long term sustainability of growth and some fears that these economies will not be able to move from a path based on imitation towards a growth trajectory based on the introduction of new products and processes. Even for the countries of new accession to the EU, data on innovative activities, on the amount and distribution of expenditure, on the sources, objectives and hampering factors, and on the network of relationships within national systems of innovation provide a picture rich in national specificities, but with little room for optimism (see Eurostat, 2008).

Although these countries show different patterns in terms of income, educational attainments of the labour force, infrastructure, institutions, quality of regulations (Aghion, 2008), innovation data witness a systematic gap in innovation generation with respect to the rest of Europe – independently from firm dimension – and in systemic interactions among actors of the national innovation system. Moreover, a frequent shortcoming is the excessive dependence on a single industrial production, usually with low value added (Hogselius, 2003). Such problems are partly due to the current process of restructuring, but the excessive fragmentation of firms and the lack of a critical mass of industrial and technological capabilities mean that the systemic interactions necessary to generate, exchange and recombine knowledge among producers and users remain inadequate. This may hinder the learning process and the progress from a pure imitative strategy to the domestic generation of technological knowledge.

These challenges clearly emerge from a number of empirical studies. In a microeconomic study of the first Croatian CIS (covering the years 2001-2003), Aralica et al. (2008) analyse the determinants of innovative activities, showing that demand plays the dominant role, while human capital and R&D have only a weak impact on the propensity to innovate.

Knell and Srholec (2006) - using the third CIS - analyse the role played by FDIs and multinational corporations in technology transfer to the Czech Republic. They conclude that foreign subsidiaries have more propensity to cooperate globally than locally, and that the subset of national firms with international cooperations look for similar partners. It appears that operating behind the technological frontier implies for local firms a difficulty in accessing knowledge flows and a weakening of the spillover effects from multinational corporations to local firms.

Another set of studies have assessed the impact of innovation on productivity. Vahter (2006) uses data from the third wave of the Estonian CIS (including both manufacturing and services), finding that the impact of product and process innovation is positive and significant over both total factor and labour productivity. Masso and Vahter (2008) carry out a similar exercise matching CIS three (1998-2000) and four (2002-2004) with balance sheet data. They found that product innovation is the main determinant for the first wave, while process innovation becomes the leading factor in the second one. They interpret the results as evidence of a different behaviour of Estonian firms during the business cycle.

Other empirical evidence on the relation between innovation and productivity comes from Roud (2007), who uses data from the Russian innovation survey for 2005, comparable with the CIS. The positive relation of product and process innovation with productivity is confirmed, and a key role appears to be played by the presence of public funding.

### *3.2 East Asia*

Many Asian countries – South Korea, Taiwan, Singapore, Malaysia, Thailand and China – have innovation surveys based on the Oslo Manual[7].

Malaysia led the group in 1995. In the 1990s Malaysian industrial and technology policy favoured the construction of a national system of innovation oriented towards new technologies, less dependent on foreign affiliates of multinationals and more oriented towards local and regional channels of technology flows. This is the picture provided by the last survey (referring to the years 2002-2004). Four fifths of Malaysian innovative firms are controlled by national capital and two thirds of them are relatively young (they were born in the 1990s), innovate both in products and processes, rely on internal sources and on local partnerships. Innovation performances in Malaysian manufacturing are therefore comparable with European standards, with a large share of turnover related to new and improved products.

South Korea has collected in a systematic way data on innovation since 1996, and the resulting database has been used for monitoring economic progress. Sung (2004) uses the 2002

[7] A private survey following the Oslo Manual has been realized also in Sri Lanka, mainly addressing the issue of entrepreneurship; preliminary evidence can be found in De Mel et al. (2009).

survey to analyzes the determinants of innovative activity, finding that technological opportunities and networking have a positive and significant impact on all output measures. Seo (2004) uses factor analysis to distinguish the relative importance of alternative sources (universities, research institutes, internal sources and private partnership), showing that a key role is played by internal sources. In a further contribution Seo and Lee (2004) use the same data and technique to investigate the role of hampering factors: they conclude that appropriability conditions explain a large share of the variance of innovative activity, while the opposite happens with firm size.

In a study of the determinants of innovative activity in South Korea, Shin (2003) - using data for the period 1997-1999- shows that firm size appears to be non significant, while industrial concentration emerges as a negative incentive to innovate. Moreover, technological activity seems to be stronger at the beginning of a firm's life, declining afterwards. Sung and Carlsson (2007) focus on the determinants, distinguishing high and low tech firms, stressing the role of networking effects, whose enhancing should be a priority for policy in their conclusions. Oh et al. (2007) analyze the sequence between innovative inputs, innovative outputs and productivity growth using a combination of innovation survey and financial data from other sources. R&D is not affecting innovative output, so they suggest caution in public subsidies. A similar analysis is carried out by Lee and Kang (2007), who investigate the impact of innovation output on productivity, showing that process innovation has the strongest effect.

Taiwan's first innovation survey covers 1998-2000. The results have been investigated by Shia et al. (2003), showing that around 50% of firms can be classified as innovative and that public policy is actively involved in technological development; in particular, the country has been able to exploit its structure of small and medium businesses, specializing in semi-conductors and other highly innovative industries, with strong results in innovative performances and export of high technology goods.

Singapore started to gather innovation data in 1999, for both manufacturing and a subset of business services with high technological intensity (KIBS). It is well known that the economic performance of this city-state has been very strong, with a fundamental change from an investor friendly, technology adapting country, to an economy operating at the technological frontier. An empirical investigation of this process can be found in Wong and Sing (2005), who use the 1999 innovation data and show that the transformation is still under way; while KIBS data are impressive, with 75% of innovative firms and at least 50% of firms with a 20% share of innovative turnover, manufacturing industries are still concentrated on technological adoption, with less than one third of innovative firms.

In Thailand, the empirical evidence has been used to document the fragility of the country's economy. Comparing Thailand with South Korea, Intakamnerd (2007) calculates that in 2003 the two countries show respectively six versus 43% of innovative firms, the former being too biased towards process innovation, independently of the size. The expenditure by Thailand's firms is devoted to new machinery; there is a scarce ability to exploit opportunities (even public funding is often disregarded) and to interact with other actors. Subsequent studies have confirmed this pattern of weakness; Chaminade et al. (2008) use 2003 data to detect the structural deficits through a hierarchic factorial analysis, coming to the same results.

China conducted surveys starting from 1993 and a variety of studies have resulted from them. DeBresson et al. (2006) provide detailed analyses, assessing the move of the economy from an adopter to a generator of knowledge (see also Altenburg et al. 2008; Lunnan et al. 2006 on the role of entrepreneurship). OECD (2007) defines China as a key global player in R&D and stresses that although all BRIC (Brazil, Russia, India and China) countries increased their share of high tech exports, China accounts for the largest part of this increase. The labour market impact of innovation is also investigated (see Ping et al, 2008 and Mairesse et al. 2009); the very large productivity improvements are raising concerns on the possible emergence of technological unemployment.

*3.3 Latin America*

Among the large Latin American literature resulting from the Bogotá Manual and the surveys carried out in several countries, we focus in this section on the results of the most recent wave for four large economies of the area - Brazil, Argentina, Chile and Colombia; the surveys of reference include the 2005 Argentinean ENIT (ENIT, 2005), the 2005 Brazilian PINTEC (IBGE, 2005), the Chilean 2005 survey (INE, 2005), and the 2003-2004 Colombian survey (EIDT, 2005). In methodological terms, if we compare the implementation of the surveys with the recommendations of the Bogotá Manual several problems emerge. The first issue regards the representativeness of the sample. Brazilian and Chilean surveys are on manufacturing and services, while for the other two countries the reference is only to the former. The Chilean survey focuses on industrial establishments, while the other ones investigate firms. Argentina has a stratified sample, Colombia has a census of firms with more than 10 employees (or 65 million pesos of turnover), Brazil collects data on all firms with more than 500 employees, sampling the smaller ones with a complicate technique which over-represents innovative firms; Chile adopts a standard sampling at five percent confidence level.

The second problematic issue regards the ability of the surveys to document innovative activities beyond the "success stories" of the largest firms. In the Brazilian case there is a bias towards very large and innovative firms. In the Colombian case the elimination of micro-firms is also problematic, because they represent a non negligible part of the economy.

The third problem concerns comparability, the question at the root of the Bogotá Manual; major differences in questionnaire design persist among the four countries. In the first section of the questionnaire, on background data, the Chilean survey gathers information on the share of foreign capital, turnover and exports; the Colombian one considers only the share of foreign capital; the Argentinean one disregards exports; the Brazilian one ignores exports but includes many details on who is the respondent, its charge and the geographical dimension of the market. In the second section, on innovative activities, the surveys in Brazil and Chile follow the European model, the Argentinean case is more R&D focused, leaving aside organizational activities and failed projects. Colombia considers a larger set of activities, from organizational change to training, from acquisition of machinery to R&D, but it neglects the performance part and the share of turnover due to new products, with few questions that try to relate objectives with results and concern intellectual property rights.

An additional set of problems with questionnaires concerns the sources, objectives and hampering factors for innovation. These parts provide the most direct indicators of capabilities, since they report the resources available for innovation, the strategies related to it and the hindering elements that prevent it. The Brazilian questionnaire is closer to the Oslo Manual, but there is a declination of the objectives in terms of impacts of the innovation which is clearly biased towards "success stories". The Argentinean one ignores the source of ideas, but has a specific section on the relationships with the National Innovation System, while the Chilean one is concise on the objectives. In Colombia the hampering factors are associated to a long list of objectives, and there is no attention to cooperation.

Summing up these methodological issues, we may argue that several comparability problems persist; a similar conclusion is reached by Peirano and Crespi (2004) and Anlló (2006), who have monitored the surveys and reviewed the evidence for Latin America. The surveys that are closer and comparable to the European ones - i.e. Brazil and Chile (as well as Mexico) – tend to be biased towards large firms.

Looking at the main results obtained by such surveys, we find a significant gap between Latin America and European countries in terms of R&D; the private share of R&D is less than one third of the total, while in advanced countries the proportion is almost double (Benavente et al. 2005).

*3.4 Africa*

In spite of the slow down of the development process in most African countries - where the

majority of the labour force remains employed in low productivity or subsistence agriculture - innovation has received a growing attention also in Africa. Here the opportunities for catching up and imitation are often limited by the lack of capabilities, industrial techno-structure, adequate demand and access to markets.

As an example, Diyamett and Wangwe (2006) analyse Tanzania: the country has doubled the growth rate from the 1980s to the late 1990s (from two to four percent per year), but 51% of the population remains under the poverty line. They propose a number of indicators to be considered for an innovation survey and argue that a major problem is the lack of science and technology infrastructures; the universities are poorly graded and people have limited access to them. They suggest considering more closely the role played by government R&D centres, in particular those linked with agriculture, and they propose a focus on human resources, their skills and complementarities.

The only country in Africa that has systematically performed data gathering exercises on innovation is South Africa. The country has R&D surveys covering 1991-92, 2001-02, 2003-04, and 2004-05 (Gerryts and Buys, 2008). Building on these results, two innovation surveys were conducted in 2001 and 2005. The design of the questionnaire is close to the CIS one, with a simplification of some questions (Blankley and Kaplan, 2006). The results from the R&D surveys are used to detect the likelihood of innovators, which is biasing the potential inference (Oerlemand et al. 2006); the rate of response of the survey reached 60%.

Most South African studies refer to the first innovation survey and to R&D data, because of dissemination delays in the second survey. Gettys and Buys (2008) analyze R&D as a determinant of innovative output and show that 88% of innovators conduct R&D, either internally of externally; most R&D focuses on development and little cooperation takes place with universities.

In the context of North African countries, both Morocco and Tunisia developed an interest in innovation surveys (Arvanidis and Mhenni, 2008). After a first – and more oriented to the R&D activity – survey conducted in 1999, a second survey was designed and run in Morocco in 2005, roughly following Oslo Manual guidelines.

A more systematic engagement in gathering innovation data marked the Tunisian experience, where two innovation surveys based on the Oslo Manual were carried out, covering 2002-2004 and 2005-2007. Using the first survey micro data, Ayadi et al. (2007) studied the determinants of product and process innovation and the configuration of sectoral patterns of innovation of Tunisian firms, providing a detailed analysis of the innovation process in four sectors – Agri–Food Industries; Mechanical and Metal Industries; Electrics, Electronics and Electrical Home Appliance Industries; Textile and Clothing Industries – that exhibit a superior innovation capacity (in terms of incidence of product and process innovation) compared to the manufacturing average. Their results showed that the main determinant of product innovation in Tunisian innovative firms is demand, followed by the existence of an R&D Department and the capacity to carry out technological and scientific cooperation with other actors. Regarding process innovation, competitive pressure, demand and cooperation appear to play a stimulating role. Conversely, openness to foreign markets is not associated to a higher innovation dynamism. As usual, sectoral specificities exist and matter. In a successive investigation, Ayadi et al. (2009) investigate the main determinants of the propensity to innovate by Tunisian firms. They obtain interesting evidence on the essential role played by sources of technical knowledge external to firms – such as universities, research centres, laboratories, national and international bodies, other firms and external technical assistance. These results confirm that, in order to generate innovation in firms lacking internal inventive capabilities, absorptive capacity plays a crucial role. Two other results are noteworthy; the first one concerns the negative association between state participation in the capital of firms and innovation propensity, suggesting that bureaucratic resistance to change may prevail over the potential of access to public resources for innovation. The second one regards the non monotonic role of exports: the most innovative firms are the ones that serve both domestic and foreign markets; conversely the exclusive exporters and the firms that serve only internal market lagged behind in innovation. The drivers of innovation in Tunisia were the object of another investigation

conducted by Gabsy et al. (2008), showing the presence of an "inverted U" type relationship between size of firms and market structure and the decision to innovate; they also emphasize the weak effect of skilled workers and public incentives on the innovative behaviour of Tunisian firms.

## 4. A comparative analysis

The results reviewed in the previous section show persisting problems of comparability and the methodological difficulties in studying innovation in Developing Countries; however, important progress has been made and the findings of the studies carried out on individual countries or regions report patterns that are broadly similar. In order to advance our understanding of innovation, we carry out in this section a comparison among the results of innovation surveys in a subset of countries chosen on the basis of their closeness to the Oslo Manual questionnaire and similarity of sample design; the largest economies of each continent are included in our analysis. The countries we examine include the average for the New Accession Countries of the European Union (EU-NAC)[8], Russia, Ukraine, Turkey, China, South Korea, Malaysia, Thailand, Singapore, Taiwan, South Africa, Argentina, Brazil, Chile, Colombia[9]. We consider the average values for the core group of the European Union (EU-15) as terms of reference typical of advanced economies.

We investigate the time period between 2002 and 2006, choosing the appropriate wave of innovation surveys in each country. When data are not available or accessible, we choose the closest wave. In the Appendix we indicate the source, with the years covered and the statistical sampling used.

In tables 1-5 below, we show - for the selected countries - the results of innovation surveys for the following key dimensions:

a) the innovative output, in terms of new products and processes, and share of innovative turnover;
b) the structure of innovative expenditure, focusing on the core distinction between R&D and acquisition of new machinery;
c) the sources of knowledge, distinguishing between internal, external (clients or suppliers) and institutional, taking into account also the existence of public funding for innovation;
d) the objectives of innovation, that allow to identify the different strategies of innovating firms;
e) the hindering factors, that are crucial to understand the barriers to innovation.

Data refer to the total of manufacturing or services, providing an aggregate picture of the overall innovative activities in an economy[10].

Table 1 shows that in general EU-15[11] outperforms emerging countries in terms of innovative output, but the degree of variability among the latter is very large. There are a few Asian countries – such as South Korea – whose performances are comparable or higher than the EU-15. Most emerging countries and EU-NAC have innovative outputs that are moderately behind EU levels. A few countries lag behind the EU by a substantial margin – such as Russia, Ukraine and Thailand. It should be pointed out here that data on the share of innovative firms report the introduction of new products or new processes that are new to the firm (rather than new for national

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8 New Accession Countries of the European Union (EU-NAC) include the following countries of Central and Eastern Europe: Bulgaria, Cyprus, Czech Republic, Estonia, Latvia, Lithuania, Hungary, Malta, Poland, Romania, Slovenia, Slovakia.

9 When analyzing data for Malaysia, South Africa and Brazil, we should keep in mind that the sampling design is biased towards innovators, so the results are likely to be an upper bound.

10 As shown by a large literature, the strong differences in innovative patterns across industries and the frequent concentration of technological activities in a limited number of industries present in Developing Countries suggest that an industry break down would greatly improve our understanding of the position of each country. Limitation in access to data has made more detailed data not available.

11 When considering data for EU-15 - a benchmark for advanced countries - we should keep in mind a few caveats. EU-15 data are unweighted averages of values for the 15 countries, that include some economies with limited innovative activities. European countries are characterised by slow growth, industrial decline, consolidated markets and strong international integration, and this reflects on their innovative performances.

or international industries); likewise, data on innovative turnover refer to the share of sales of products that are new to the firm, including therefore both innovation and imitation; for example, Malaysia has a 42% share on innovative turnover, but the percentage which does not result from imitation is about 14%. In Developing Countries these variables are mainly an indicator of the extent of imitation and of the ability to modernise production and find new markets, that in turn is affected by the growth of domestic and foreign demand. This explains why Asian countries and China have such strong performances on both variables. The cases of Brazil and South Africa are affected, as already pointed out, by the over-representation of innovative firms in the surveys. Conversely, countries with slow-growing economies, such as Eastern Europe, Russia and others, show much lower shares of innovative firms and turnover. The position of EU-15 reflects the strength of advanced countries in terms of shares of innovative firms and the consolidation of a large and integrated production system where firms report relatively low (and stable) shares of innovative sales. In presence of strong capabilities and competition, and with slow growth of markets, it is unlikely that most firms can reach and sustain a high share of innovation-related sales.

**Table 1. Innovative output.**

Legend: M Manufacture, S services, KIBS refers to knowledge intensive business services

| Countries | Manuf. or Serv. | Share of Innovative Firms | Product and Process (as share of innovative firms) | Product Only (as share of innovative firms) | Process Only (as share of innovative firms) | Share of turnover due to new, improved products |
|---|---|---|---|---|---|---|
| EU NAC | M | 30.7 | 48.2 | 22.0 | 24.9 | 11.5 |
| | S | 23.8 | 42.0 | 23.0 | 28.1 | 11.1 |
| EU 15 | M | 48.9 | 45.2 | 21.3 | 27.7 | 10.4 |
| | S | 41.5 | 41.7 | 22.7 | 30.7 | 6.3 |
| RUSSIA | M | 9.3 | | | | 10.6 |
| | S | 15.3 | | | | 3.1 |
| UKRAINE | M | 11.5 | | | | 6.7 |
| TURKEY | M | 35.3 | | 25.1 | 25.0 | |
| | S | 24.6 | | 16.7 | 18.5 | |
| CHINA | M | 30.0 | 21.3 | 3.8 | 4.8 | 14.4 |
| SOUTH KOREA | M | 42.0 | 18 | 18 | 5 | 54 |
| | S | 21.0 | | | | |
| MALAYSIA | M | 53.8 | | 10.6 | 6.2 | 42* |
| THAILAND | M | 6.4 | | 4.10 | 4.3 | |
| | S | 4.0 | | | | |
| TAIWAN | M | 39.6 | | 27.6 | 27.2 | |
| | S | 32.4 | | 23.2 | 20.4 | |
| SINGAPORE | M | 31.7 | | 24.1 | 22.4 | 29 |
| | KIBS | 56.9 | | 44.4 | 49.4 | |
| SOUTH AFRICA | M | 54.8 | 38.4 | 11.1 | 3.5 | 13.7 |
| | S | 49.3 | 22.9 | 12.7 | 7.3 | 7.6 |
| ARGENTINA | M | 41.7 | | | | |
| BRAZIL | M | 33.3 | | | | 38.7 |
| | S | 51.7 | | | | 50.4 |
| COLOMBIA | M | 33.4 | | | | |
| CHILE | M, S | 37.9 | | | | 24.9 |

*includes turnover due to imitation
Sources: see Appendix.

Table 2 reports the share of innovative expenditures devoted to R&D and to the acquisition of technology through the adoption of new machinery and equipment. The distance between the EU-15 and emerging countries in terms of R&D efforts is here evident; among the countries for which data are available only Turkey has a limited lag. EU-NAC and Developing Countries concentrate their resources in new machinery in order to modernize their production systems.

**Table 2. Innovative expenditure.**

Legend: M Manufacture, S services, KIBS refers to knowledge intensive business services

| Countries | Man. or Serv. | R&D as share of total expenditure | New machinery and equipment as share of total expenditure |
|---|---|---|---|
| EU NAC | M | 20.1 | 78.9 |
| | S | 21.8 | 65.9 |
| EU 15 | M | 56.0 | 36.3 |
| | S | 48.0 | 39.3 |
| RUSSIA | M | 15.7 | 61.7 |
| | S | 6.2 | 78.4 |
| UKRAINE | M | | |
| TURKEY | M | 32.0 | 64.0 |
| | S | 42.9 | 53.7 |
| CHINA | M | 37.3 | 54.5 |
| SOUTH KOREA | M | | |
| | S | | |
| MALAYSIA | M | | |
| THAILAND | M | 32.6 | 51.3 |
| | S | 15.1 | 25.6 |
| TAIWAN | M | | |
| | S | | |
| SINGAPORE | M | | |
| | KIBS | | |
| SOUTH AFRICA | M | 27.2 | 71.3 |
| | S | 26.4 | 63.0 |
| ARGENTINA | M | 15.3 | 64.4 |
| BRAZIL | M | 20.5 | 48.3 |
| | S | 48.1 | 14.7 |
| COLOMBIA | M | 2.61 | 70.8 |
| CHILE | M,S | 19.2 | 46.6 |

Source: see Appendix.

The main sources that firms consider highly important in the innovations they introduced are reported in Table 3 (data do not add up to 100 as they show the share of firms indicating each source as relevant; Turkey has very high values in all categories, suggesting a low reliability of data). Knowledge internal to firms is by far the dominant source of innovation; as this category includes both R&D efforts typical of more advanced economies and technical and design competences typical of emerging ones, there is little differentiation among countries. The important role of clients in "pulling" innovations is evident in several countries – including China – while universities as sources of of innovation play a role in a few countries only. The share of innovating firms receiving public funding is highest in the EU-15 and rather low in other countries, with the exception of Latin America.

**Table 3. Sources of Innovation and Public Support.**

Legend: M Manufacture, S services, KIBS refers to knowledge intensive business services
Data are expressed as shares of innovative firms

| Countries | Man. or Serv. | Internal Sources | Suppliers | Clients | Universities | Firms receiving public financing for innovation |
|---|---|---|---|---|---|---|
| EU NAC | M | 39.1 | 23.6 | 28.5 | 3.1 | 14.7 |
| | S | 39.8 | 24.1 | 30.0 | 3.4 | 10.0 |
| EU 15 | M | 47.7 | 26.8 | 29.3 | 5.4 | 32.9 |
| | S | 49.3 | 26.4 | 30.9 | 4.0 | 18.0 |
| RUSSIA | M | 2.4 | 2.1 | 4.9 | 0.3 | |
| | S | 3.2 | 4.6 | 4.4 | 0.3 | |
| UKRAINE | M | | | | | 3.7 |
| TURKEY | M | 71.0 | 72.8 | 74.4 | 23.4 | 22.6 |
| | S | 70.0 | 73.7 | 73.8 | 24.8 | 8.8 |
| CHINA | M | 37.9 | 21.6 | 59.7 | 8.9 | |
| SOUTH KOREA | M | | | | | 10-30 |
| | S | | | | | |
| MALAYSIA | M | 29.3 | 27.9 | 41.9 | 5.7 | |
| THAILAND | M | | | | | |
| | S | | | | | |
| TAIWAN | M | | | | | |
| | S | | | | | |
| SINGAPORE | M | | | | | |
| | KIBS | | | | | |
| SOUTH AFRICA | M | 54.3 | 25.9 | 43.7 | 10.2 | 11.9 |
| | S | 44.9 | 23.1 | 26.2 | 1.1 | 1.6 |
| ARGENTINA | M | 8.2 | 21.1 | 21.1 | 9.5 | 1.6 |
| BRAZIL | M | 50.8 | 40.0 | 43.0 | 0.1 | 19.2 |
| | S | 74.8 | 37.3 | 46.6 | 11.5 | 37.7 |
| COLOMBIA | M | 79.0 | 11.7 | 22.6 | 4.6 | 31.7 |
| CHILE | M/S | 49.8 | 39.4 | | 14.6 | 16.7 |

Source: see Appendix.

**Table 4. The Objectives of Innovation.**

Legend: M Manufacture, S services, KIBS refers to knowledge intensive business services
Data are expressed as shares of innovative firms

| Countries | Man. or Serv. | Quality Improvement | Range of Products | New Markets | Productive capacity | Flexibility | Labour cost | Other cost |
|---|---|---|---|---|---|---|---|---|
| EU NAC | M | 32.2 | 30.0 | 24.9 | 25.9 | 22.7 | 13.3 | 11.9 |
| | S | | | | | | | |
| EU 15 | M | 37.5 | 33.0 | 28.5 | 26.6 | 26.9 | 20.4 | 12.3 |
| | S | | | | | | | |
| RUSSIA | M | 34.0 | 40.5 | 21.3 | 17.7 | 15.2 | 3.7 | 7.2 |
| | S | 55.9 | 50.3 | 15.0 | 27.1 | 25.8 | 2.9 | 5.6 |
| UKRAINE | M | | | | | | | |
| TURKEY | M | 83.4 | 76.8 | 74.2 | 79.4 | 78.4 | 68.1 | 55.0 |
| | S | 82.1 | 70.0 | 77.0 | 77.4 | 76.5 | 54.3 | 42.3 |
| CHINA | M | 49.2 | 45.2 | 47.3 | 47.3 | 32.5 | 31.9 | 37.5 |
| SOUTH KOREA | M | 63.0 | 46.0 | 52.0 | 45.3 | 43.0 | | |
| | S | 41.5 | 32.8 | 25.0 | | 17.5 | 24.2 | 25.0 |
| MALAYSIA | M | | | | | | | |
| THAILAND | M | | | | | | | |
| | S | | | | | | | |
| TAIWAN | M | | | | | | | |
| | S | | | | | | | |
| SINGAPORE | M | 48.3 | 44.6 | 29.9 | 16.0 | 16.1 | 14.4 | 13.3 |
| | KIBS | 43.6 | 25.1 | 17.8 | 22.0 | 14.5 | 2.2 | 2.2 |
| SOUTH AFRICA | M | 48.3 | 44.6 | 29.9 | 16.0 | 16.1 | 14.4 | 13.3 |
| | S | 43.6 | 25.1 | 17.8 | 22.0 | 14.5 | 2.2 | 2.2 |
| ARGENTINA | M | | | | | | | |
| BRAZIL | M | 68.4 | 42.0 | 28.1 | 58.0 | 48.3 | 38.5 | 39.7 |
| | S | 82.5 | 69.3 | 46.3 | 66.4 | 62.3 | 35.3 | 33.8 |
| COLOMBIA | M | 53.4 | 26.5 | 31.7 | 46.3 | 25.5 | 24.4 | 24.0 |
| CHILE[12] | M/S | 51.8 | | 60.1 | 59.1 | 59.1 | | 59.1 |

Source: see Appendix.

Table 4 shows the main objectives of innovation; strategies based on new and improved products may be linked to a search for new markets and a wider product range, while efforts focused on production processes may lead to greater capacity and flexibility, or lower labour and other production costs (again, data do not add up to 100 as they show the share of firms indicating each objective as relevant; Turkey has again very high values in all categories). Quality improvement appears as the dominant objective in emerging countries, associated to other product-related efforts; in parallel, innovation in processes aims at strengthening the productive capacity - especially in Asia and Latin America – with concerns on labour costs playing a more limited role.

The barriers to innovation are highlighted in Table 5 (again, data do not add up to 100 as they show the share of firms indicating each barrier as relevant; Turkey has very high values in all categories). Firms in Developing Countries report that the dominant barrier to innovation is the lack of funds - due either to the high costs of innovation or to the lack of internal or external funds

[12] Chilean data on objectives should be taken with caution, because the proposed alternatives are very different.

available – while the lack of human resources, information and demand constraints have a less relevant role. In most of these factors, emerging countries report higher difficulties than firms in EU-15[13].

**Table 5. Hampering Factors.**

Legend: M Manufacture, S services, KIBS refers to knowledge intensive business services
Data are expressed as shares of innovative firms

| Countries | Man. or Serv. | Innovation Cost | Lack of internal resources | Lack of external financing | Lack of human Resources | Lack of information on technologies | Lack of information on markets | Lack of demand | Structure of the market |
|---|---|---|---|---|---|---|---|---|---|
| EU NAC | M | 27.4 | 27.3 | 22.4 | 14.9 | 7.9 | 8.8 | 15.6 | 18.5 |
| | S | 18.0 | 17.2 | 15.3 | 10.9 | 7.2 | 7.3 | 11.8 | 15.2 |
| EU 15 | M | 22.2 | 22.3 | 15.4 | 13.5 | 7.3 | 7.9 | 13.4 | 14.8 |
| | S | 17.7 | 18.2 | 12.7 | 11.9 | 6.1 | 7.8 | 12.3 | 12.9 |
| RUSSIA | M | 22.8 | 40.3 | 19.9 | 6.2 | 3.4 | 3.4 | 6.7 | |
| | S | | | | | | | | |
| UKRAINE | M | | | | | | | | |
| TURKEY | M | 71.1 | 67.9 | 57.5 | 68.3 | 63.0 | 50.1 | 62.3 | 53.2 |
| | S | 64.6 | 59.1 | 49.0 | 59.2 | 47.6 | 45.8 | 61.1 | 50.4 |
| CHINA | M | 5.5 | | | 4.5 | | | 6.5 | |
| SOUTH KOREA | M | | | | | | | | |
| | S | | | | | | | | |
| MALAYSIA | M | | | | | | | | |
| THAILAND | M | | | | | | | | |
| | S | | | | | | | | |
| TAIWAN | M | | | | | | | | |
| | S | | | | | | | | |
| SINGAPORE | M | | | | | | | | |
| | KIBS | | | | | | | | |
| SOUTH AFRICA | M | 15.5 | 32.4 | 16.3 | 15.3 | 5.9 | 1.1 | 3.3 | 14.0 |
| | S | 29.3 | 26.6 | 20.7 | 25.1 | 1.3 | 5.2 | 14.9 | 30.9 |
| ARGENTINA[a] | M | 10.5 | 31.0 | 3.0 | 17.4 | 4.1 | 3.9 | 16.7 | 15.4 |
| BRAZIL[b] | M | 80.6 | 77.4 | 77.4 | 38.7 | 16.1 | 45.2 | 19.4 | |
| | S | 67.1 | 48.0 | 48.0 | 57.6 | 29.2 | 38.3 | 26.4 | |
| COLOMBIA | M | 36.3 | 22.4 | 22.4 | 24.4 | 23.2 | 25.5 | 27.5 | 29.3 |
| CHILE[c] | M/S | 58.8 | 31.8 | 31.8 | 47.6 | 25.0 | 25.0 | 38.1 | |

Source: see Appendix.

a. The Argentinean questionnaire asks about *high risk* and not *high cost* of innovation.

b. Brazil does not distinguish between internal and external source of financing, so the total value is reported in both columns.

c. Chilean data do not consider the lack of markets, w and we have replaced it with

[13] Hampering factors tend to correlate positively with the resources invested in innovation, a clear evidence that innovation is a matter of capabilities, i.e. of *seeing* the opportunities and the difficulties. When we move towards countries closer to the technological frontier, we may find that data are more representative of the problems encountered by the universe of firms and not just by the more innovative ones. Moreover, in a subjective survey firms may point out the lack of funds as an issue that sums up all problems. In the case of Colombia, where we have investigated the microdata of the second innovation survey (2003-2004), when we run a regression of innovative expenditures on the hampering factors we have always positive (and sometimes significant) coefficients for all factors except financing, which is negative and significant; technically, we run Tobit-II and hurdles models, so the estimates are robust to the sample selection induced by the survey (non innovators do not fill in this part of the questionnaire).

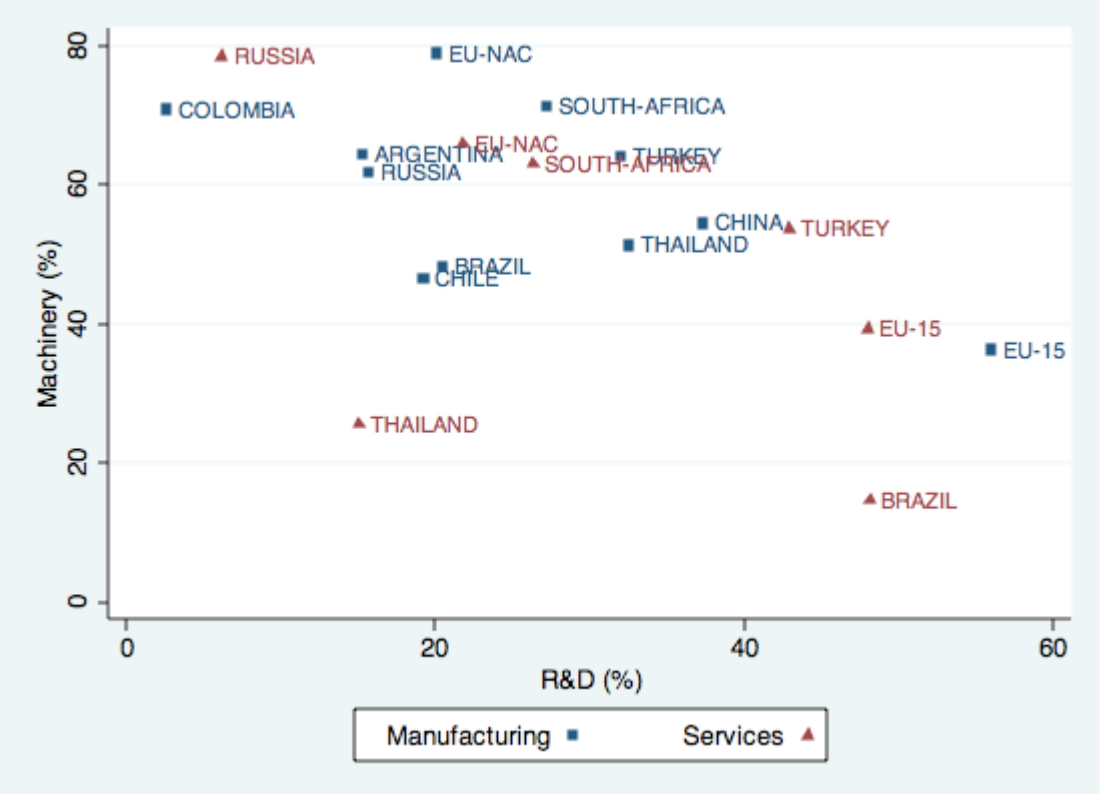
information on "long period of return"; there is no distinction between the two types of information problems, and the total value is reported in both columns.

In the evidence above a systematic comparison between manufacturing and service industries has been provided. Results are generally consistent, showing that innovation can be found throughout the economy; innovative efforts and outputs are likely to be stronger in manufacturing, but services are likely to follow closely in most countries; innovation in knowledge intensive business services tends to be higher than in manufacturing. Some specificities emerge on the basis of particular variables: in manufacturing there is a greater role of acquisition of new machinery and costs are a heavier constrain; in services, internal sources of innovation are more important and public funding is lower.

A preliminary way of summarizing this evidence on innovation in emerging countries is to combine key dimensions of technological efforts – for both manufacturing ans services - in the figure below. Figure 1 shows the trade off between the two major priorities in the expenditure on innovation - on the one hand the prevalence of R&D, typical of countries closer to the technological frontier and engaging in original innovation; on the other hand the concentration of resources on the introduction of new production technologies (usually developed elsewhere) through the acquisition of new machinery and equipment. Countries in the process of industrialisation tend to devote the large majority of their technological efforts to the latter; this is the case of Latin America (with the exception of Brazil), Russia, South Africa, but also of the Central and Eastern European countries that have recently joined the EU. On the other hand, China, other Asian countries and Turkey have an intermediate position, devoting their efforts in roughly equal shares to R&D and new machinery; this shows that such countries are moving closer, at least in some sectors, to the European pattern of expenditure for innovation.

**Figure 1. R&D and acquisition of new machinery in selected countries.**

Data are expressed as share of total innovation expenditure.



Source: see Appendix.

The evidence on innovation can be examined in terms of regional and country patterns, considering also the information offered by more traditional R&D, investment and education indicators (Table 6 in the Appendix summarises this evidence).

Central and Eastern European countries of new accession to the EU show a substantial gap relatively to the EU-15 in terms of shares of innovative firms (about 30% against 50%) and in terms of the relevance of internal sources of innovation (about 40% against 50%), while a broad convergence appears in other variables - innovative sales, other sources, objectives. The key indicator of the existing gap, however, is the low value of R&D expenditure (one third of the share of the EU-15) and the dominance of the acquisition of new machinery (with a share double than in the EU-15). Russia and Ukraine share similar problems and show a much larger gap with the European innovative performances.

The position of Turkey appears closer to the EU-15 averages in most of these variables, suggesting a stronger process of industrialisation and a more solid national science and technology infrastructure.

China shows these same characteristics, supported by the very high growth rates of the economy, with strong demand "pulling" innovative sales. The most advanced Asian countries - South Korea, Taiwan and Singapore - have innovative performances and shares of R&D in GDP that are similar to those of the EU-15, with a strong internal generation of innovation and attention to product improvement in the objectives of innovation. Conversely, Malaysia and Thailand lag behind in a number of key indicators.

Latin America shows weaker performances in innovation that are associated also to the patterns of industrialisation that have emerged in the last two decades. The opening up of the economies in the 1990s and the introduction of competitive pressure have operated in the direction of improving efficiency through the adoption of technologies developed in advanced economies. The previous model of industrialization through import substitution - inspired in the 1960s by the structuralist approach of CEPAL - was successful in leading to a *take off*, but not in putting those countries on a sustainable growth path (also for the endemic inefficiency of the government and the negative impact of the military dictatorships imposed in the 1980s for geopolitical reasons). In current developments, however, there are two main shortcomings: on the one hand, the adoption of technology developed for economies with a different factor content has worsened the already unequal wage distribution through skill biased technical change (Attanasio et al, 2003; Lee and Vivarelli, 2004); on the other hand, macroeconomic stability is not a sufficient condition for the domestic generation and accumulation of knowledge, especially in presence of structural capability gaps. Even Chile, which is generally praised for the good management of the economy, has a much weaker innovative performance when compared to countries with a similar income per capita (Benavente et al. 2005). The result is that all indicators of knowledge generation and innovative performance (R&D, product innovation, innovative turnover, etc.) maintain a gap versus developed and emerging countries, with the exception of Brazil, where a group of high performance firms has emerged (De Negri, et al. 2007c). Finally, among the structural problems of Latin America, we should keep in mind the productivity gap determined by an informal sector that on average accounts for 40% of GDP.

South Africa has several problems in common with Latin American countries, including the weakness of industrialisation and science and technology infrastructures, a large informal economy and slow growth and demand expansion, resulting in modest innovation performances.

## 5. Stylized facts on innovation and development

Building on the existing literature - in particular Abramovitz (1986), Lall (1992), Freeman

and Louça (2001), Perez (2002) and Nelson (2006) - and based on the empirical evidence summarised above, we can now propose the following stylized facts on innovation and development.

*Developing Countries have distinct patterns of innovation from countries at the technology frontier.* Comparisons between advanced and developing countries should be aware that innovation involves two largely different processes in the two groups of economies. In the former, a strong R&D capability and science and technology infrastructure is needed to acquire and develop the knowledge and competences needed to operate at the technology frontier; in the latter technological change mainly takes the form of acquisition of new machinery and imitation of the products and processes developed elsewhere. Both technology adoption and imitation can spread rapidly among firms in emerging countries, with the benefits typical of catching-up processes.

*Innovation needs both resources and integration of national systems.* In Developing Countries the gaps are not simply of a quantitative nature - the amount of R&D, of higher education, of high technology investment - but concern the nature of the national system of innovation, with a lack of integration between firms in the production system, the financial sector, research and education activities and the policies of the public sector. The evidence on the sources of knowledge and obstacles to innovation points out the importance of a coherent innovation system.

*Innovation is pushed by industrialisation and pulled by growth of markets.* On the supply side, innovation is closely linked to the process of industrialisation, as shown by the dominance of new machinery among innovative expenditures. One of the necessary requirements for development is the emergence of modern services, and an important empirical finding is that innovation in services has a relevance that is often close to the levels found in manufacturing. On the demand side, countries with strong economic growth and integration in international markets are able to rapidly diffuse modern production competences adopting new process technologies and new machinery, and to find expanding markets for products that imitate those of advanced countries. Industrialisation with technology adoption and growing markets with imitation appear as highly complementary developments in the countries that are most successful in the catching up process.

*Large firms are more likely to engage in innovation or spend for it*. This traditional Schumpeterian thesis is generally confirmed also in Developing Countries, where the polarisation of the industrial structure tends to be stronger than elsewhere. The capital intensive nature of innovation - considering the importance of investment in new machinery - means that the relevance of large firms (usually in "Fordist" industries) is stronger than in advanced countries, while the space for small high technology firms (for example in ICTs) is rather limited[14].

*Being exposed to international competition favours innovation*. Firms that face external competition tend to adopt technology faster (an efficiency effect *à la* Arrow, 1962), a result that has emerged also in advanced countries[15]. However, this finding does not mean that developing economies may benefit from opening up to trade and foreign competition in all industries; where domestic capabilities are inadequate and dynamic scale economies are not yet reached, opening up may simply put domestic firms out of business, losing part of the production system. The search for a trade off between these opportunities and risks is a matter better left to national industrial policies.

*The affiliates of multinational corporations tend to be more innovative*. Innovative activities occurring in the affiliates of multinational corporations tend to be higher than the national average[16]. This result has emerged also in advanced countries (Castellani and Zanfei, 2006), and is

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[14] In studies of the determinants of innovation, Langeback and Vasquez (2007) found this result for Colombia, Turriago (2003) for Argentina, Colombia and Venezuela, Benavente (2005a), (2005b) and (2006) for Chile. Chudnovsky et al. (2006) for Argentina, Johnson (2002) for Brazil, and finally Goncalves et al. (2008) for Argentina and Brazil. Partial confirmation can be found in Marotta et al. (2007), whose coefficient for large firms is significant for Colombia but not for Chile.

[15] The supporting evidence can be found in Alvarez (2001) for Chile, Goncalves et al. (2008) for Argentina and Brazil, Marotta et al. (2007) for Chile, Correa (2005) for a sample of a metropolitan area in Colombia.

[16] See Langeback and Vasquez (2007) for Colombia, Alvarez (2001) and Benavente et al. (2005) for Chile, while for

linked to intra-firm knowledge flows and to the strategies by foreign firms aiming to exploit their competences and technologies in local markets. However, in Developing Countries the integration between foreign affiliates and local firms is often modest and the spillover effects in terms of knowledge, competences and productivity can be small.

*The main obstacle to innovation is its economic cost and the lack of finance.* While this result can be found also in advanced countries, in emerging ones the dimension of the problem is more serious, and can be interpreted as an indicator of the difficulties of small and medium enterprises that dominate the industrial structure of Developing Countries (Benavente et al., 2005; Prochnik and Dias, 2005). The absence of advanced and forward-looking financial systems ready to fund long term technology projects and the lack of venture capital are contributing to such obstacles, and represent a major weakness of national innovation systems in Developing Countries.

It should be pointed out that some of these stylised facts are common to the trajectory of development of countries that are now advanced, in particular of "latecomer" economies in Southern Europe, that experienced a "take-off" in the 1950s and 1960s (see Antonelli et al. 2007 for the case of Italy).

*5.1 Different trajectories in innovation and development*

Studies on technology and development have often underplayed the variety of the sources and patterns of innovation and the importance of technological trajectories, defined (Dosi, 1982) as the dominant pattern of accumulation of technological and production capabilities, introduction of innovation and economic performance that can characterize firms, industries and countries in their development process. Our previous work on advanced countries has identified different innovative strategies, - e.g. technological competitiveness, active and passive price competitiveness (see Pianta, 2001) – that have specific consequences on the evolution of performances, growth, employment and distribution. Building on the empirical evidence provided by innovation surveys, we can now propose a typology of *four trajectories* linking innovation and development.

a) *Technological dependency* is typical of countries with little industrial base, where the main part of the economy is made up by agriculture or by few export commodities. The lack of a technological infrastructure prevents the exploitation of foreign technology, so it becomes difficult even to imitate. Technology - its different forms - is generally acquired from abroad.

b) *Passive technological capabilities* is characterized by the acquisition of foreign technologies by domestic firms through new machinery and learning processes, leading to new productions, but with no internal innovative capabilities. This pattern may be typical of economies that are resource intensive, commodities exporting or at the first stages of offshore production; they tend to be unable to build a critical mass of domestic knowledge base.

c) *Integration in international technology networks* is the pattern typical of open economies with close links between foreign owned domestic firms and the system of international production of multinational firms. We can find here transfer of technologies, growing production capabilities and participation to innovative activities, mainly through the acquisition of new machinery. This may lead to positive innovative performances, but with a limited consolidation of the domestic knowledge base.

*d) Independent technological capabilities* is a trajectory characterized by the development of internal innovative capabilities and activities by domestic firms (ranging from R&D to design, imitation and adaptation of foreign know how), leading to new productions for the internal and international markets, and the ability to compete with advanced countries at least in some industries.

Elements of these different trajectories may coexist in different industries of emerging

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Brazil we can quote Costa and Robles (2002).

countries, and the empirical documentation offered by innovation surveys may further articulate the variety of the innovative patterns that are associated to the development process. The international comparison we have offered and the stylised facts we have identified show how the use of innovation surveys can shed new light on the complexity and specificities of technological change in Developing Countries. This may have important policy implications for national actions and international governance in the fields of knowledge production and diffusion, rules on intellectual property rights, national innovation systems, investment and industrialisation efforts, trade and foreign investment regimes.

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## Appendix

We report here a set of variables on technology and industry that can be compared with the innovation data of previous tables. R&D expenditure and employment are a proxy for the knowledge base; the share of gross fixed capital formation is an indicator of investment and technology adoption; the share of manufacturing on GDP provides evidence of industrialisation, expansion of the formal economy and technology use; Foreign Direct Investment (FDI) on GDP is an indicator of international openness and dynamism; the share of people with secondary education is a measure of human capital.

**Table 6. Selected indicators for emerging countries**

| Country | R&D as a share of GDP 2000 | R&D empl. per thous. Labour Force 2000 | Gross fix. capital form. as a share of GDP, avg. 2002-2006 | Manuf. industry as a share of value added avg. 2002-2006 | FDI as a share of GDP avg. 2002-2006 | Secondary education as share of popul. aged 25-64, avg. 2002-2006 |
|---|---|---|---|---|---|---|
| EU-15 | 1.91 | 5.5 | 19.46 | 26.40 | 0.034 | 64.92 |
| EU-NAC | 0.68 | 2.9 | 23.49 | 31.68 | 0.071 | 75.55 |
| RUSSIA | 1.09 | 5.0 | 20.62 | 36.05 | 0.018 | 78.06 |
| UKRAINE | 0.96 | 3.1 | 21.36 | 33.43 | 0.040 | 88.28 |
| TURKEY | 0.48 | 0.9 | 19.32 | 28.59 | 0.010 | 26.75 |
| CHINA | 0.99 | 0.8 | 42.17 | 46.66 | 0.032 | |
| SOUTH KOREA | 2.65 | 4.9 | 29.66 | 37.18 | 0.007 | 77.42 |
| MALAYSIA | 0.48 | 0.6 | 22.30 | 47.92 | 0.030 | 21.49 |
| THAILAND | 0.25 | 0.3 | 27.10 /27.65 | 43.57 | 0.037 | |
| TAIWAN | 2.05 | 5.6 | 18.58 | 27.59 | -0.011 | 64.18 |
| SINGAPORE | 1.87 | 5.8---7.6 | 19.98 | 32.42 | 0.126 | 45.59 |
| SOUTH AFRICA | 0.70 | 0.8 | 17.81 | 31.51 | 0.010 | 13.92 |
| ARGENTINA | 0.43 | 1.2 | 18.24 | 34.71 | 0.022 | 40.38 |
| BRAZIL | 0.99 | 1.9 | 16.76 | 28.78 | 0.024 | 36.80 |
| CHILE | 0.54 | 0.6 | 20.44 | 46.92 | 0.058 | 73.13 |
| COLOMBIA | 0.24 | 0.1 | 20.39 | 32.54 | 0.035 | |

Sources:

- column two, three and four: Lederman and Saenz (2005); Eurostat New Cronos Database; World Bank,World Development Indicators database; South Africa Human Science Research Council; Association of Southeast Asian Nations (2010), S&T Indicators/Technology Competitiveness Indicators.
- column five: World Bank, 54 indicators; Taiwan Council for Economic Planning and Development (2009), Taiwan Statistical Data Book.
- column six: both FDI and GDP are expressed in current USD; for countries outside Europe the average covers 2002-2005; World Bank, 54 indicators; Taiwan Council for Economic Planning and Development (2009), Taiwan Statistical Data Book.
- column seven: ILO, LaborSta; OECD Labour Force Statistics, Education at Glance; Taiwan Statistical Data Book.

In Table 7 below we report the details on the innovation surveys analyzed in the article, listing the wave of reference, years, population covered and sampling procedures. The publications used for each country as sources of the data reported in our tables are listed in the bibliography.

**Table 7. Details on the Innovation Surveys considered.**

| Country | Wave | Years | Population | Sample |
|---|---|---|---|---|
| EU-15 | IV | 2002-2004 | Manufacturing and Services | Stratified sample (above ten employees) |
| EU-NAC | IV | 2002-2004 | Manufacturing and Services | Stratified sample (above ten employees) |
| ARGENTINA | IV | 2005 | Manufacturing | Stratified sample |
| BRAZIL | III | 2003-2005 | Manufacturing and some services | All firms with more than 500 (100) employees in manufacturing (services); sampling below the threshold; biased towards innovators |
| CHILE | IV | 2003-2004 | Manufacturing | Stratified sample |
| CHINA | I | 2004-2006 | Manufacturing | All firms with a turnover larger than 5 millions won |
| COLOMBIA | II | 2003-2004 | Manufacturing | All firms with more than 10 employees |
| MALAYSIA | IV | 2002-2004 | Manufacturing | Stratfified sample of firms with more than 5 employees |
| RUSSIA | | | | |
| SINGAPORE | I | 1996 | Manufacturing and High Tech Services (KIBS) | Stratified sample |
| SOUTH AFRICA | II | 2002-2004 | Manufacturing and Services | Stratified sample, innovators are detected through the use of R&D surveys, thus the sample may be biased. |
| SOUTH KOREA | | 2002-2004 | Manufacturing | Stratified sample of firms with more than ten employees |
| TAIWAN | III | 2007 | Manufacturing and Services | Stratified sample of firms with more than 5 employees |
| THAILAND | III | 2003 | Manufacturing and Services | Stratified sample of firms with more than 10 employees |
| TURKEY | V | 2004-2006 | Manufacturing | Stratified sample of firms with more than 10 employees |
| UKRAINE | | | | |

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