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Innovation Patterns and Their Effects on Firm-Level Productivity in South Asia

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Abstract

This paper describes and benchmarks innovation activities for a sample of countries in the South Asia region, as well as the impact of these activities on firm-level productivity. The evidence gathered suggests that countries in the South Asia region can be divided into two groups, in terms of the magnitude and composition of the innovation activities: leaders (Bangladesh and India) and laggards (Nepal and Pakistan). Leaders present higher rates of innovation activities than laggards and focus more on process innovation than product innovation. Differences across firms within all countries tend to present similar patterns when considering leaders and laggards, with the acquisition of knowledge capital (for example, research and development investments in equipment, and training) highly concentrated in a few firms, and mature, exporter, and foreign-owned firms as the most innovative of the region. The evidence also suggests a positive impact of innovation on productivity, primarily via incremental innovation, especially in India.

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Innovation Patterns and Their Effects on Firm-Level Productivity in South Asia

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1. Why Innovation Matters

Innovation is at the center of the development process. It is the engine of the "creative destruction" process needed to spur economic dynamism and transformation (Schumpeter, 1942). Innovation increases employment more than contracting it with technological change (Harrison et al., 2008; Cirera and Sabetti, 2019). Further, it is an important prerequisite for successful participation and upgrading of small and medium-sized enterprises (SMEs) in Global Value Chains (GVCs) (OECD 2008). Process and organizational innovation increase firm productivity by reducing production costs and allowing firms to achieve the minimum level of efficiency required to cover the fixed costs of exporting. Product innovation creates learning-by-doing effects and helps firms to offer new and upgraded products, either through product or inter-chain upgrading; while marketing innovation and innovative branding strategies allow firms to differentiate their products from those of their competitors and gain market share in global value chains. Innovation is also a key determinant of firm-level productivity (Crepon et al., 1998), affecting both the "within" and "between" components of aggregate productivity growth. The within component is related to individual firms becoming more productive; that is, increasing the amount of output they produce with a constant amount of input-either through process and/or organizational innovation-while the between component is associated with the reallocation of factors of production, such as labor and capital, towards more innovative firms, forcing inefficient firms to exit the market.

Innovation can contribute to poverty reduction; since it can generate large productivity gains. Evidence shows that not all transitions from poverty require a change in the type of work undertaken, but an increase in workers' wages, which can be obtained through efficiency improvements gained through innovation. In Bangladesh and Vietnam, for example, poverty transitions have been dominated not by changes in income sources from farm to non-farm income, but by higher income within the same sector (Dang and Lanjouw, 2012). This is also the case in Sub-Saharan Africa, where poverty reduction in rural areas is more closely associated with increases in farm productivity. China offers additional insight into this, as increasing labor productivity in agriculture has been a key factor to understanding poverty reduction in lagging Chinese provinces (Christiaensen et al., 2009).

Innovation can also contribute to shared prosperity. By fostering productivity and employment growth, innovation can directly increase the income of the bottom 40 percent of a nation's population. Although it is worth mentioning that innovation may increase income inequality if the technology used to develop new products and/or processes is biased towards skilled labor. Theories of biased technical change show that non-neutral technologies can increase the skill premium and, therefore, widen the wage gap between skilled and unskilled workers (Acemoglu, 1998). On the other hand, when process innovation reduces product prices; and if goods produced with more efficient technologies represent a disproportionate portion of the consumption basket of poor people, then innovation increases the purchasing power and well-being of the bottom 40 percent.

Despite the large amount of evidence supporting the positive impact of firm-level innovation, policy makers in developing countries face significant challenges to design policy frameworks and programs that boost firm-level innovation and productivity. Innovation and productivity play a prominent role in explaining income differences across developed and developing countries, and one stylized fact about firm dynamics across the world is the presence of large dispersion in firm attributes and performance, even within very narrowly defined sectors; suggesting that policies that target the average firm--as was traditionally done in the past--may end up not having a relevant impact if the distributions of firm attributes and performance are significantly dispersed. While much policy attention has focused on innovation and productivity determinants that are external to the firm, such as competition policy or policy distortions in factor and product markets, few policy measures, if any, have sought to address one of the most important determinants of productivity: firm-level innovation activities. One reason for this knowledge gap has been due to a dearth of data at the firm level in the developing world that can inform policy makers. A key objective of this paper is to provide an empirical overview of firm-level innovation activities in the South Asia region - Bangladesh, India, Nepal, and Pakistan - and explore its causal links, when possible, to firm-level productivity.

This paper is structured as follows: Section 2 describes the main findings in the literature. Section 3 talks about the main challenges of measuring innovation and the data used for this paper. Section 4 describes the main patterns in terms of investments in knowledge capital. Section 5 explores innovation patterns. Section 6 examines the links between innovation and productivity. The final section presents the main conclusions.

2. What Does the Literature Say about the Causal Effects of Innovation on Productivity?

For several years, policy makers and researchers have emphasized the role of factor accumulation as a way to foster economic progress. However, after the last two decades of empirical research on economic growth, economists have concluded that total factor productivity (TFP)--a measure of improvements in efficiency and technological progress--explains the bulk of cross-country differences in both the level and growth rate of per capita GDP (Easterly and Levine, 2001). Since then, several empirical attempts have been conducted to identify the sources of productivity growth at the firm level. Within this literature, exploring the causal links between innovation and productivity has become a key priority for both policy makers and academics, as innovation can affect firm-level productivity through several channels. For example, process innovation increases efficiency in the use of intermediate inputs and factors of production; product innovation creates learning-by-doing effects that make firms more competitive; while organizational innovation encourages the reallocation of inputs and factors of production across activities within firms, enhancing production efficiency.

Recently, two well-known surveys conducted by Hall (2011) and Mohnen and Hall (2013) provide a comprehensive overview of the channels and effects of innovation on firm-level productivity. Their surveys pay special attention to the results of papers that have been trying to address the causality and endogeneity problems of innovation inputs and outputs in a convincing way. Therefore, their reviews focus mainly on papers that have been using the Crepon, Duguet, and Mairesse (1988) (CDM) model. Two different empirical strategies have been employed in the literature when estimating this model. One approach uses Asymptotic-Least-Squares, which embodies the joint estimation of the main equations of the model. The other approach estimates a sequential model, where predicted values of endogenous variables in the first stage are included in the estimation of the second- and third-stage equations. A main conclusion from Hall et al. (2009) and Musolesi and Huiban (2010), who compare the results from both methods, is that there are not significant differences in the impact of innovation on productivity as long as endogeneity and selection are properly treated.

The literature has used continuous and dichotomous innovation variables to estimate their effects on productivity. According to Mohnen and Hall (2013), results from 12 papers, most of them from developed economies, suggest that the elasticity of firm-level productivity with respect to the intensity of product innovation--measured as the contribution in total sales of the new products developed in the last three years--is positive and in most of the cases statistically significant. Although results vary in terms of their quantitative impact, the most common value for the productivity elasticity to product innovation intensity is 0.25; suggesting that an increase of 10 percent in the latter variable raises productivity by 2.5 percent. Further, there seems to be heterogeneity of impact across different sectors, as Criscuolo' s (2009) findings show that the elasticity tends to be higher in manufacturing than in services sectors.

Two important regularities have been identified from the literature review, which relies mainly on the empirical evidence provided by developed countries: (i) product innovation tends to have a larger impact on firm-level productivity than process innovation, although there are methodological issues that can rationalize the lack of relevance or negative effect of process innovation on productivity, such as the fact that most of the productivity measures employed in the literature are calculated using firm revenues, which do not capture the positive cost-saving and induced price-reduction effects of process innovation on firm performance; (ii) innovation effects related to "product and process innovations" or "technological and non-technological innovations" tend to vanish when the contributions of different types of innovations to firm productivity are jointly estimated, suggesting the potential presence of complementarities between both types of innovations.

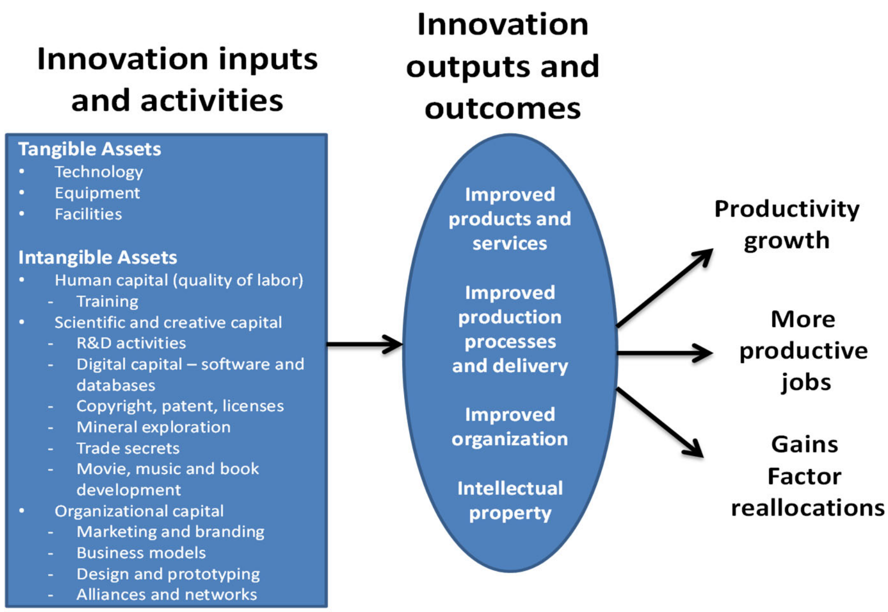
The conclusions presented above summarize the findings of papers reviewed by Mohnen and Hall (2013), who have divided them in three groups: (i) those that only consider process innovation measured through a dichotomous variable; (ii) those that include product and process innovation together in the same equation; and (iii) those that distinguish between technological and non-technological innovations. Most of the papers in the first group, which includes Huergo and Jaumandreu (2004), Van Leeuwen and Klomp (2006) and Criscuolo (2009), find that process innovation is either negatively correlated with productivity or not statistically significant. Papers in the second group, which involves the contributions by Mairesse et al. 2005, Parisi et al. 2006, Duguet 2006, Griffith et al. 2006, Chudnovsky et al. 2006, Roper et al. 2008, Mairesse and Robin 2008, and Hall et al. 2009, find that product and process innovation are statistically significant to explain productivity gains at the firm level only when they are included separately, but often their effects vanish if their contributions are jointly estimated. There are some cases, however, where product innovation is still relevant after controlling for process innovation (Griffith et al. 2006, Mairesse and Robin 2008). The third set of papers, Loof and Heshmati 2006, Masso and Vahter 2008, Raffo et al. 2008, Musolesi and Huiban 2010, and Siedschlag et al. 2010, find that technological and non-technological innovation are important determinants of productivity if their effects are separately estimated. But similar findings to the second group are observed when both coefficients are jointly estimated, giving some signs of the presence of collinearity effects due to the potential existence of complementarities between both types of innovations.

3. Challenges in Measuring Innovation

Innovation requires the transformation of knowledge capital or innovation inputs, both tangible and intangible–such as training, equipment, R&D or intellectual property acquisitions–into innovation outcomes and outputs, for instance, the introduction of new products, improved quality, new production processes, or organizational changes (See Boxes 1 and 2). Firms invest in these knowledge capital inputs in order to increase their capabilities and produce innovative outcomes. As well as requiring tangible assets such as technology, equipment, and the physical production facilities, innovation needs intangible assets such as human capital, scientific and creative capital, and organizational capital. In turn, these inputs require specific innovation activities. Firms invest in training in order to increase the available human capital. In addition, firms invest in R&D, software, and digitalization or copyrights, patents and licenses in order to increase their scientific or innovative capital. Finally, innovation also requires organizational capital through investments in marketing and branding, adoption of new business models, design and prototyping, or corporate alliances and networks.

As illustrated in Figure 1, the combination of these inputs yields innovation outputs in the form of new or improved products and services, production and delivery processes, business organization, and patented intellectual property. However, achieving the outcomes is heavily dependent on the ability of the firm in question, on the specific sector and country context, and on the enabling environment and policy framework in place.

Figure 1. The Innovation Function



Source: Authors own elaboration

To measure innovation, one can focus on both measuring inputs and innovation activities and/or on innovation outputs. A challenge, however, when measuring innovation outcomes is the subjective nature of many of the questions used in the surveys. The Oslo manual 3rd edition (OECD/EUROSTAT(2005)), which is the main reference for these types of surveys, defines innovation as "…..the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations." Most surveys use this definition to identify innovations by directly asking firm managers and owners whether they have implemented "new" or "significant" changes or improvements in the last three years.[2] This is problematic since "significant" improvement is a highly subjective term and is also self-reported.[3]

In general, any sound analysis of innovation activity should combine a focus on both knowledge capital inputs and innovation outputs. Although the innovation module of the Enterprise Survey does not provide information on all relevant intangible assets, it provides information on various sources of knowledge capital and innovation outputs as shown in Boxes 1 and 2.

[2] The ES uses the following introduction to the questionnaire: "I would like to start by asking you some questions about any new or significantly improved product or service introduced by this establishment, where "new" means new to the establishment and not necessarily new to the market."

[3] The new edition of the Oslo Manual introduces "differs significantly" in the definition, to rule out small changes OECD/EUROSTAT(2018).

Box 1. Innovation Activities in the Enterprise Survey

Innovation or knowledge inputs are activities that are associated with the development of innovation at the firm level.
They are grouped into 5 categories:

i. Research and development
The firms were surveyed on the source of R&D (internal vs external) as well as expenditure.
ii. Capacity building
The firms reported on the training provided as a result of new innovations introduced as well as expenditure.
iii. Purchase/licensing of inventions or other knowledge forms
The firms reported on the expenditure on the purchase of inventions or intellectual property that helped them come up with innovations.
iv. Acquisition of business intelligence
The interviewed firms reported on what were the key sources of information and ideas for their innovative activities.
v. Intellectual property
On this, firms reported on whether they applied for patents, utility models, trademarks, copyright design or registered an industrial design.

Box 2. Innovation Outputs from the Enterprise Survey

Similar to the innovation surveys based on the Oslo Manual, the innovation module of the Enterprise Survey measures the following types of outcomes:

i. Product innovations
ii. Process innovations
iii. Organizational innovations
iv. Marketing innovations

Product innovations are essentially new, redesigned, or substantially improved goods or services. In the context of the survey, there are 3 metrics used:

a. New products to the firm,
b. Significantly improved products,
c. New products to the market.

Process innovation is the implementation of new or significantly improved production or delivery methods (including significant changes in techniques, equipment, and/or software). Minor changes or improvements, an increase in production or service capabilities through the addition of manufacturing or logistical systems which are very similar to those already in use, ceasing to use a process, simple capital replacement or extension, changes resulting purely from changes in factor prices, customization, regular seasonal and other cyclical changes, trading of new or significantly improved products are not considered to be innovations.1 Specifically:

a. Innovation methods for manufacturing products or offering services,
b. Innovative logistics, delivery, or distribution methods for inputs, products, or services,
c. Innovative supporting activity for processes, such as maintenance systems or operations for purchasing, accounting, or computing.

Organizational innovation means the implementation of a new organizational method in business practices, workplace organization, or external relations. The kind of innovation is grouped into structural innovations which is meant to impact responsibilities, accountability, command lines, and information flows, as well as the number of hierarchical levels, the divisional structure of functions (research and development, production, human resources, financing, etc.) or the separation between line and support

functions, and procedural innovations, which consists of changes to routines, processes, and operations of a company. Thus, these innovations change or implement new procedures and processes within the company, such as simultaneous engineering or zero buffer rules.
Marketing innovation is a change made to incorporate the advances in marketing science, technology or engineering to increase the effectiveness and efficiency of marketing, to gain competitive advantage.

In order to examine the innovative behavior of firms in the South Asia region, we use the World Bank Enterprise Survey and its specific innovation module implemented in the region during the 2014 and 2015 years. The survey, which compiles data from face-to-face interviews, uses a stratified sampling method where firms are stratified by industry, size, and location. Firm-size levels are 5-19 (small), 20-99 (medium), and 100+ employees (large-sized firms). Since in the South Asia region most firms are small and medium-sized, the Enterprise Survey oversamples large firms. Overall, the data set has around 5,500 observations unevenly distributed between the four South Asian countries. For instance, the number of firms surveyed in India surpasses what was surveyed in the other three countries jointly (see Table 1). Regarding the sector composition of the sample, more than 4,000 firms belong to the manufacturing sectors, while only 1,266 firms operate in services. The survey targeted formal firms only and excludes micro firms, although few firms in the survey are de facto micro as they had fewer than 5 employees.

Table 1. Sample composition

	Manufacturing			**Services and other**			**Total**
	small(<20)	**Medium (20-99)**	**Large (100 and over)**	**small(<20)**	**Medium (20-99)**	**Large (100 and over)**	
Bangladesh	228	323	301	80	44	11	987
Pakistan	191	222	107	41	45	18	624
India	647	1,199	791	261	334	196	3,428
Nepal	89	102	43	188	42	6	470
Total	1,155	1,846	1,242	570	465	231	5,509

Source: Enterprise Survey (2014)

The innovation survey differentiates between two types of technological innovations (product and process) and two types of non-technological innovations (organization and marketing). However, since the survey relies on subjective interpretations of innovative activities, there is significant confusion when identifying the different types of innovation. For example, new marketing processes, like discounts, new packaging or new client segments, are sometimes misconstrued with process or product innovations. The fact that interviewees provide a recorded description of product and process innovations allows the user to verify the identified innovations and reclassify wrongly attributed cases to their respective category or invalidate cases that do not constitute an innovation at all. This exercise has been conducted by Cirera and Sabetti. 2019, who provided “clean innovation data” (see Appendix for methodological description). For the overall sample of South Asia firms, the cleaning exercise conducted by the authors has decreased both product innovation - from 53% to 51% - and process innovation rates from 64% to 58%. Although the cleaning exercise reduced innovation rates for most countries, Nepal is an exception where product innovation increased from 10% to 12% as the result of reclassification from process innovations.

4. Investments in Knowledge Capital

R&D investments are one of the main drivers of long-term economic growth. The accumulation of capital, whether in the form of physical assets such as plants and equipment or through better human capital, cannot indefinitely sustain growth unless new R&D investments are made with the purpose of creating new products, services, processes and/or developing and implementing new business models or organizational reforms (Solow, 1957). Increasing R&D investments is an important priority for advanced countries, but it also has an important role to play in developing countries and emerging economies.

Catching-up with the countries at the technology frontier requires not only imitating what they have done, but also adapting it to the particular country circumstances. R&D investment is also required to address some of the specific, yet very important, challenges that developing countries face. And very often developing countries, free from the constraints of existing systems and infrastructure, can skip existing technologies and develop new radical innovations (as leapfrogging examples from Kenya's M-Pesa mobile banking to India's frugal innovation methods demonstrate) (Bravo-Biosca et. al., 2014). Further, firms in sectors with high intensity of R&D spending, referred to as high-tech sectors, are often catalysts of large economic gains.

However, due to the existence of positive externalities firms tend to invest in R&D less than the socially optimal level. R&D is an input of the innovation process and R&D activities can frequently generate spillovers since inventors rarely can fully appropriate the returns that their innovation activity generates. Inventors can use intellectual property, secrecy or first-mover advantage among other strategies to capture the returns from their innovation activities. However, this cannot prevent other firms learning from both an inventor's success but also failures (which can also provide valuable lessons), and replicate, fully or partially, some of her successes, whether launching similar products or services, or adopting similar processes or business models. As a result of these spillovers, the social return to investments in R&D is higher than the private return, and markets invest less in R&D than socially optimal. This market failure is a common rationale for several innovation policy interventions, such as R&D tax credits and grants, which aim to close the wedge between social and private returns to R&D by increasing the latter.

Evidence about R&D underinvestment has been documented by Bloom, Schankerman, and Van Reenen (2005), who find, using a sample of U.S. firms, that public benefits of firms engaging in R&D were roughly twice as high as private benefits. R&D also plays a key role in helping countries to catch-up to the technological frontier, with evidence suggesting that the returns to R&D are greater for countries that are far from it (Griffith et al., 2004). Although empirical evidence shows that poor countries display the lowest rates of R&D investment despite their potential for large gains. This fact is partially explained by the presence of countervailing effects related to the scarceness of complementary factors (Goni and Maloney, 2014).

In the context of developing countries, therefore, the focus on innovation inputs should be put in knowledge activities more broadly defined, as firm learning and investments in knowledge are also important drivers of innovation. Ideas that generate innovation are not costless and information used to produce those ideas, even if freely available, requires some type of investment or capability on the part of the user in order to fully expropriate its benefits. For example, Cohen and Levinthal (1989) describe internal R&D efforts of firms as a dual process of creating new knowledge, but also enhancing their ability to assimilate and exploit external knowledge, i.e., absorptive capacity.

In this subsection, we focus on describing the nature of knowledge investments in our sample. The subjective nature of the questions regarding innovation outcomes, as well as their self-reported nature, emphasizes the need to also look at other knowledge activities beyond investments in R&D. Thus, we will start our discussion by focusing on R&D, both intramural – done inside the firm – and extramural – outsourced outside the firm – and then we will explore other activities such as training, acquisition of equipment and licenses.

4.1 Knowledge capital intensity

R&D activity tends to be highly concentrated in several countries, indicating that only a small share of firms conducts the bulk of aggregate R&D. One country that stands out is India, where the incidence of R&D is the highest in the region, and the concentration rate is low, implying that even though the average intensity of R&D –R&D expenditure in dollars for a given year for those firms that carry out R&D - is low compared to the average of the ECA region, many firms are investing in R&D. Innovation leaders (e.g., Bangladesh and India) present a larger percentage of firms conducting R&D than the average of the ECA and Africa regions, while laggards display a lower percentage. The same regional ranking applies for R&D expenditures per employee, although the region presents a poor performance compared to the standards of the ECA region. Although the distribution of R&D intensity is biased to the left for most types of firms, the top of the distribution indicates larger values for large, mature, foreign-owned, and trader firms.[4] Intramural R&D is the main source of R&D for all the South Asian countries.

Table 2. Knowledge capital intensity

Type	Indicator	Bangladesh	Pakistan[B]	India	Nepal	South Asia	ECA	Africa
R&D	% firms	19%	6%	56%	4%	21%	9%	19%
	Per Employee[a]	33.17	-	47.66	14.33	354.5	1663	249.14
	Intramural %	16%	6%	53%	3%	19.3%	8%	16.5%
	Extramural %	5%	3%	7%	1%	4%	4%	7%
Training	% firms	21%	12%	43%	6%	21%	-	20%
	Per Employee	175.96	455.72	59	142.358	175.96	-	303.56
Equipment	% firms	75%	17%	68%	23%	46%	-	29%
	Per Employee	473.17	267	2,358.45	3409.17	1626.95	-	3017.23
License	% firms	5%	3%	4%	1%	3%	-	8%
	Per Employee	52.04	492	39.40	205.43	197.21	-	151.56

[a] Intensity for firms doing R&D [b] For Pakistan only 23 firms with information available
Source: Author's elaboration from Enterprise Survey (2014)

Investments in equipment appear as the most important investment in knowledge capital (except for Pakistan). Leaders do more training than laggards, with nearly half of Indian firms providing training to their workers and spending an amount per employee that doubles that of the laggard group. However, all countries in the region have spent less money on training per worker than on R&D. Few firms in the SAR acquired new licenses.

The pattern of R&D is very heterogeneous when considering firm characteristics, both within and across country groups (Table 3). In India, small, non-exporters, national and very young firms are more R&D intensive, while in Bangladesh, the pattern is slightly different, with large, exporters, foreign and old firms as more R&D intensive.[5] More importantly, In Pakistan there is a very large concentration of R&D activity in an extremely low number of firms.

[4] Details upon request.
[5] These findings were statistically significant.

Table 3. R&D intensity (USD) by firm type

	Bangladesh		India		Nepal		Pakistan [b]	
	Average all firms	Average firms performing R&D	Average all firms	Average firms performing R&D	Average all firms	Average firms performing R&D	Average all firms	Average firms performing R&D
Small (<20)	2.66	44.20	27.51	131.37	0.14	6.68	0.62	82.17
Medium (20-99)	7.98	59.57	19.14	62.42	3.44	50.55	82.28	2,706
Large (>100)	8.01	30.70	24.33	55.93	2.25	39.08	31.56	429.20
Non-exporter	5.33	44.22	21.02	72.27	1.40	41.91	26.24	944.76
Exporter	8.59	38.60	30.86	71.60	1.19	15.20	125.68	2,226.26
national	6.12	42.09	22.99	72.77	1.14	31.61	43.52	1,371.92
foreign (25%)	7.43	40.88	4.96	10.75	13.93	62.68		
age<5	7.54	96.16	48.19	212.04				
age 5-9	3.03	30.05	30.31	99.80	0.23	6.98	4.77	162.14
age 10-14	2.41	16.74	16.67	55.43	0.05	2.59	17.00	2,057.40
age 15-19	5.09	35.76	16.68	53.25	0.66	12.33	142.98	4,384.87
age 20+	9.14	53.66	20.10	57.79	3.79	71.00	48.07	933.99

Source: Author's elaboration from Enterprise Survey (2014) [b] For Pakistan only 23 firms with information available

5. Innovation Patterns

We start the analysis of innovation patterns by distinguishing innovations into two types: (i) technological innovations, which involve product and process inventions, and (ii) non-technological innovations, which involve organizational and marketing inventions.

5.1 Overall Pattern

Countries in the South Asia region can be divided into two groups: leaders, i.e., Bangladesh and India, and laggards, i.e., Nepal and Pakistan, according to technological innovations (Table 4). On the one hand, we find Bangladesh and India, as strong innovators, with innovation rates around roughly 80 percent, respectively, showing a performance that surpasses the average of the ECA and Africa regions. On the other hand, we find Pakistan and Nepal, with innovation rates of 14.8 percent and 21.2 percent, respectively, displaying a performance below the average of the ECA and Africa regions.

Table 4. Firm Innovation by size group (% of all firms)

Country	Size[6]	Technological			Non-Technological	
		Product	**Process**	**Prod. & Proc.**	**Organizational**	**Marketing**
Bangladesh	All	44.0%	61.4%	77.7%	37.2%	90.6%
	Small	40.9%	52.6%	75.1%	38.9%	82.7%
	Medium	37.5%	68.7%	77.8%	34.4%	93.1%
	Large	56.5%	63.2%	81.0%	40.2%	97.8%
Pakistan	All	8.1%	8.1%	14.8%	14.5%	72.0%
	Small	6.3%	3.4%	9.6%	5.2%	67.3%
	Medium	7.6%	13.6%	18.9%	14.6%	76.9%
	Large	14.8%	5.4%	17.8%	19.6%	70.4%
India	All	53.2%	60.8%	83.3%	55.3%	81.8%
	Small	45.5%	57.2%	77.3%	41.2%	79.7%
	Medium	55.9%	58.8%	85.1%	49.6%	79.8%
	Large	56.4%	67.8%	86.0%	66.1%	87.4%
Nepal	All	12.3%	10.1%	21.2%	36.9%	87.3%
	Small	9.0%	6.9%	15.4%	0.0%	84.5%
	Medium	20.2%	26.5%	41.8%	43.3%	99.4%
	Large	81.7%	11.9%	90.8%	10.5%	99.5%
ECA	All	19.3%	12.6%	26.3%	53.3%	-
	Small	18.1%	10.6%	24.3%	48.2%	-
	Medium	20.8%	15.7%	29.4%	58.5%	-
	Large	24.1%	20.0%	35.0%	66.8%	-
Africa	All	25.8%	30.6%	44.6%	42.7%	-
	Small	23.8%	28.4%	42.2%	40.2%	-
	Medium	33.0%	37.1%	51.5%	39.3%	-
	Large	31.1%	46.5%	58.4%	51.4%	-
Russian Federation	All	20.5%	16.8%	28.2%	67.9%	-
	Small	13.2%	11.7%	18.6%	55.6%	-
	Medium	24.9%	22.8%	35.2%	67.7%	-
	Large	38.7%	22.4%	48.8%	83.8%	-
Turkey	All	5.4%	6.3%	8.5%	63.1%	-
	Small	4.3%	6.8%	8.0%	58.8%	-
	Medium	5.1%	4.5%	7.0%	55.4%	-
	Large	14.2%	9.1%	17.6%	84.0%	-

Source: Author's elaboration from Enterprise Survey (2014)

Further, the composition of the innovation portfolio highlights another difference between both country groups. While process innovation is more important in Bangladesh and India, product innovation is more important in Nepal and Pakistan. However, there is convergence in the pattern of non-technological

[6] Size classification consists of: small, less than 20 employees; medium from 20 to 100 employees; large more than 100 employees.

innovations, as all the countries display high rates of marketing innovations compared to organizational innovations.

5.2 Who Are the Innovators? Identifying Innovation Patterns across Different Types of Firms

Although the characteristics of the innovation process and the main binding constrains are often the same for all types of firms, the ability to overcome the challenges and constraints linked to innovation usually varies with firm attributes and performance. For example, the idea that innovation is difficult to finance in a freely competitive marketplace has a long academic history dating back to the classic articles of Nelson (1959) and Arrow (1962). In particular, two characteristics of innovation make financing more difficult: (i) innovation produces an intangible asset and (ii) the returns to innovation investment are highly uncertain (see Hall and Lerner (2009) and Kerr and Nanda (2014) for a review). There are also financial market reasons for innovation underinvestment that exist even when externality-induced underinvestment is absent. These reasons are related to informational asymmetries (e.g., adverse selection and moral hazard problems), which create a gap between the private innovation rate of return and the cost of capital when the innovation investor and financier are different entities.

Thus, access to innovation finance can be more difficult for young and small firms, as informational asymmetries are typically a more relevant problem for start-ups and SMEs than for large and well-established firms. Young firms are generally small and have very limited assets that can be used as collateral, while older firms with an existing portfolio of products and some assets face lower overall uncertainty (since the success of the firm is not necessarily linked to a single product launch) and, in addition, they typically have some assets that can be pledged as guarantee. Large established firms not only have a large asset base that can be used as collateral/guarantee, but they also have a broad portfolio of products and a diversified pipeline of innovation projects, as well as access to a wider range of sources of capital at a lower cost. Therefore, even if the outcome of their innovation projects is both uncertain and intangible, they have much less difficulty accessing finance than small firms.

Exporters and importers tend to be more innovative than domestic firms, although the causal relationship between "being and importer/exporter" and "being an innovator" can go in both directions. This happens because access to international markets can affect the incentives to innovate, but vertical innovations e.g., process or quality upgrading can also facilitate access to the world trade system by reducing the minimum idiosyncratic level of productivity/efficiency required for a firm to cover the fixed costs of exporting, while product innovation allows a firm to increase the range of products supplied in foreign markets.

Access to international markets either through exporting activities or the acquisition of intermediate or final goods contributes to the absorption of international knowledge and the diffusion of cutting-edge ideas, which helps product innovation (Lileeva and Trefler, 2010). Access to cheaper intermediate inputs allows within-firm reallocation of resources to innovative activities, and the market share gains obtained in international markets through the reduction of production costs can help a firm to overcome the fixed cost of innovating. Further, reductions in tariffs raise the value of exporting firms and lower the value of non-exporting firms generating a reallocation of process innovation towards exporting firms (Atkeson and Burstein, 2010). Finally, the increase in revenues produced by trade integration can induce exporters to upgrade their technology or introduce process innovations (Bustos, 2011; De Loecker 2007).

Foreign-owned firms are usually more innovative than domestic firms for several reasons: (i) they are endowed with more financial and human resources to innovate, (ii) they often sell their products in several locations, which gives them the advantage of diluting the fixed cost of innovating across several markets (Brambilla, 2009), (iii) if related to institutional ownership, foreign-owned firms increase innovation incentives through reducing career risks (Aghion et al., 2013), and (iv) they transfer knowledge to local workers or incentivize the reallocation of domestic skilled workers and talent to their firms.

5.3 Evidence for the South Asia Region

Differences across size-groups: A comparison of innovation patterns across different types of firms classified by size shows that in most of the cases, technological and non-technological innovation rates are higher for larger firms than for smaller ones, displaying a pattern that is consistent with other regions such as ECA and Africa (Table 4). Using a *student t* test for equality of proportions between groups,[7] we find that these differences are statistically different across almost all types of innovation in India and Nepal. The test results also suggest that large firms have a statistically greater proportions for product and marketing innovation in Bangladesh and for organizational innovation in Pakistan. In addition, the gap of innovation rates across different size-groups varies significantly across countries. While there is a large proportion of small firms innovating relative to the proportion of medium-sized and large firms in India, the proportion of small firms innovating relative to large firms in Nepal is low.

Differences across age-groups: The evidence whether mature firms tend to be more innovative than young firms in terms of introducing technological inventions (Table 5) is mixed. In India, younger firms display higher rates of organizational innovation and marketing that are statistically different than mature firms.

Table 5. Firm Innovation by age group (% of all firms)

		Technological			Non-Technological	
Country	**Size**	**Product**	**Process**	**Product & Process**	**Organizational**	**Marketing**
Bangladesh	All	44%	61%	78%	37%	91%
	Mature	44%	61%	78%	37%	91%
	Young	42%	63%	82%	33%	85%
Pakistan	All	8%	8%	15%	15%	72%
	Mature	8%	7%	14%	16%	72%
	Young	9%	23%	31%	-	70%
India	All	53%	61%	83%	55%	82%
	Mature	53%	61%	83%	54%	81%
	Young	57%	63%	87%	74%	92%
Nepal	All	12%	10%	21%	37%	87%
	Mature	13%	10%	22%	38%	87%
	Young	8%	5%	14%	-	99%
ECA	All	19%	13%	26%	53%	-
	Mature	20%	13%	27%	53%	-
	Young	14%	11%	19%	58%	-
Africa	All	26%	31%	45%	43%	-
	Mature	26%	31%	45%	42%	-
	Young	26%	30%	45%	40%	-
	All	21%	17%	28%	68%	-

[7] Because sample size varies across countries, the strength of tests of statistical significance will vary. Tests statistics are available in a technical appendix.

Russian Federation	Mature	20%	18%	28%	64%	-
	Young	22%	12%	28%	82%	-
Turkey	All	5%	6%	9%	63%	-
	Mature	6%	7%	9%	65%	-
	Young	1%	1%	2%	27%	-

Source: Author's elaboration from Enterprise Survey (2014).

Differences across trader-status groups: Trader firms i.e., exporter, importer or both, tend to be more innovative in both dimensions (technological and non-technological) than non-trader firms (Table 6), with relatively larger gaps between groups for process innovation. However, these differences are statistically different in few cases. Further, the proportion of innovative firms within the non-trader group in leading countries is larger than the proportion of innovative firms in laggard ones. The overall innovation dynamic of the region is consistent with what is the average behavior in other regions such as ECA and Africa.

Table 6. Firm Innovation by Trade Status (% of all firms in each category)

	Technological innovation			**Non-technological**	
Country	**Product**	**Process**	**Product & Process**	**Organizational**	**Marketing**
Bangladesh					
No Trader	42%	59%	77%	34%	89%
Trader	48%	68%	79%	43%	95%
Pakistan					
No Trader	7%	8%	13%	14%	69%
Trader	15%	9%	21%	17%	85%
India					
No Trader	53%	59%	83%	55%	82%
Trader	55%	66%	83%	56%	82%
Nepal					
No Trader	12%	9%	20%	33%	87%
Trader	14%	21%	31%	54%	92%
ECA average					
No Trader	16%	10%	22%	52%	-
Trader	26%	20%	36%	57%	-
Africa average					
No Trader	25%	30%	44%	41%	-
Trader	31%	34%	50%	48%	-
Russian Federation					
No Trader	18%	14%	25%	62%	-
Trader	37%	33%	47%	87%	-
Turkey					
No Trader	2%	3%	4%	46%	-
Trader	10%	12%	15%	72%	-

Source: Author's elaboration from Enterprise Survey (2014)

Differences across importer and exporter groups: In all the SAR region except in Pakistan, exporters are more innovative than importers in terms of creating new products; but importers and two-way traders are more innovative than exporters regarding process and organizational innovation (except for Nepal) (Table 7). Further, in all the countries expect Pakistan, two-way traders introduce more marketing innovations than the rest of the groups. The innovation dynamic is different for the other two regions used for benchmarking. While the two-way trader group is the most innovative in ECA, no matter the type of innovation considered, this is true in Africa for process and organizational innovations. Indeed, importers are the most innovative group in terms of inventing new goods in Africa.

Table 7. Innovation by Trade Status (% of all firms in each category)

Country	Category	Product	Process	Prod.	Organizational	Marketing
Bangladesh	No Trader	42%	59%	77%	34%	89%
	Importer	37%	71%	79%	43%	94%
	Exporter	46%	62%	79%	38%	95%
	Two-way	54%	74%	79%	48%	97%
Pakistan	No Trader	7%	8%	13%	14%	69%
	Importer	69%	17%	76%	25%	97%
	Exporter	10%	1%	11%	13%	88%
	Two-way	7%	31%	32%	20%	71%
India	No Trader	53%	59%	83%	55%	82%
	Importer	52%	65%	75%	65%	76%
	Exporter	62%	61%	82%	47%	80%
	Two-way	31%	83%	89%	78%	93%
Nepal	No Trader	12%	9%	20%	33%	87%
	Importer	13%	13%	25%	49%	100%
	Exporter	9%	24%	34%	40%	81%
	Two-way	48%	53%	53%	88%	100%
ECA	No Trader	16%	10%	22%	52%	-
	Importer	25%	24%	38%	44%	-
	Exporter	25%	16%	34%	60%	-
	Two-way	30%	29%	46%	64%	-
Africa	No Trader	25%	30%	44%	41%	-
	Importer	34%	38%	55%	46%	-
	Exporter	28%	32%	48%	45%	-
	Two-way	36%	50%	59%	58%	-
Russian Federation	No Trader	18%	14%	25%	62%	-
	Importer	37%	22%	44%	72%	-
	Exporter	37%	33%	47%	89%	-
	Two-way	30%	38%	44%	74%	-
Turkey	No Trader	2%	3%	4%	46%	-
	Importer	36%	24%	36%	7%	-
	Exporter	10%	10%	12%	67%	-
	Two-way	9%	23%	27%	92%	-

Source: Author's elaboration from Enterprise Survey (2014)

<u>Difference across ownership groups:</u> In all the countries of the SAR region except in Pakistan, foreign-owned firms are more innovative both in technological and non-technological terms. However, differences in the innovation rate of domestic and foreign firms are relatively minor in the case of India when we look at product and process innovation. While this pattern is similar to the observed in ECA; it is different to the one displayed in Africa, where domestic firms introduce more products than foreign-owned ones. These findings are statistically different for product and process innovation in Bangladesh, product and process innovation simultaneously in India, marketing in Nepal, and process innovation and marketing in Pakistan.

There is a mismatch between R&D investment behavior and differences in innovative behavior across types of firms and countries. For example, while in India small or domestic firms show more R&D intensity, they are not necessarily more innovative. This is likely to reflect the fact that as we will see below, a significant amount of innovation activity is imitation – innovation that is only new to the firm – and this may require some R&D but not large R&D intensity.

Table 8. Innovation by Foreign Status (% of all firms in each category)[8]

		Technological			Non-Technological	
Countries	**Category**	**Product**	**Process**	**Product & Process**	**Organizational**	**Marketing**
Bangladesh	All	44%	61%	78%	37%	91%
	Domestic	44%	61%	77%	37%	91%
	Foreign	73%	81%	92%	40%	96%
Pakistan	All	8%	8%	15%	15%	72%
	Domestic	8%	9%	15%	15%	71%
	Foreign	8%	0%	8%	13%	13%
India	All	53%	61%	83%	55%	82%
	Domestic	53%	61%	83%	55%	82%
	Foreign	53%	61%	95%	42%	81%
Nepal	All	12%	10%	21%	37%	87%
	Domestic	12%	10%	21%	37%	87%
	Foreign	28%	28%	28%	55%	100%
ECA	All	19%	13%	26%	53%	-
	Domestic	18%	12%	25%	52%	-
	Foreign	26%	15%	34%	65%	-
Africa	All	26%	31%	45%	43%	-
	Domestic	27%	31%	45%	43%	-
	Foreign	21%	31%	41%	41%	-
Russian Federation	All	21%	17%	28%	68%	-
	Domestic	19%	17%	26%	64%	-
	Foreign	50%	22%	71%	96%	-
Turkey	All	5%	6%	9%	63%	-
	Domestic	4%	5%	7%	57%	-
	Foreign	32%	32%	33%	98%	-

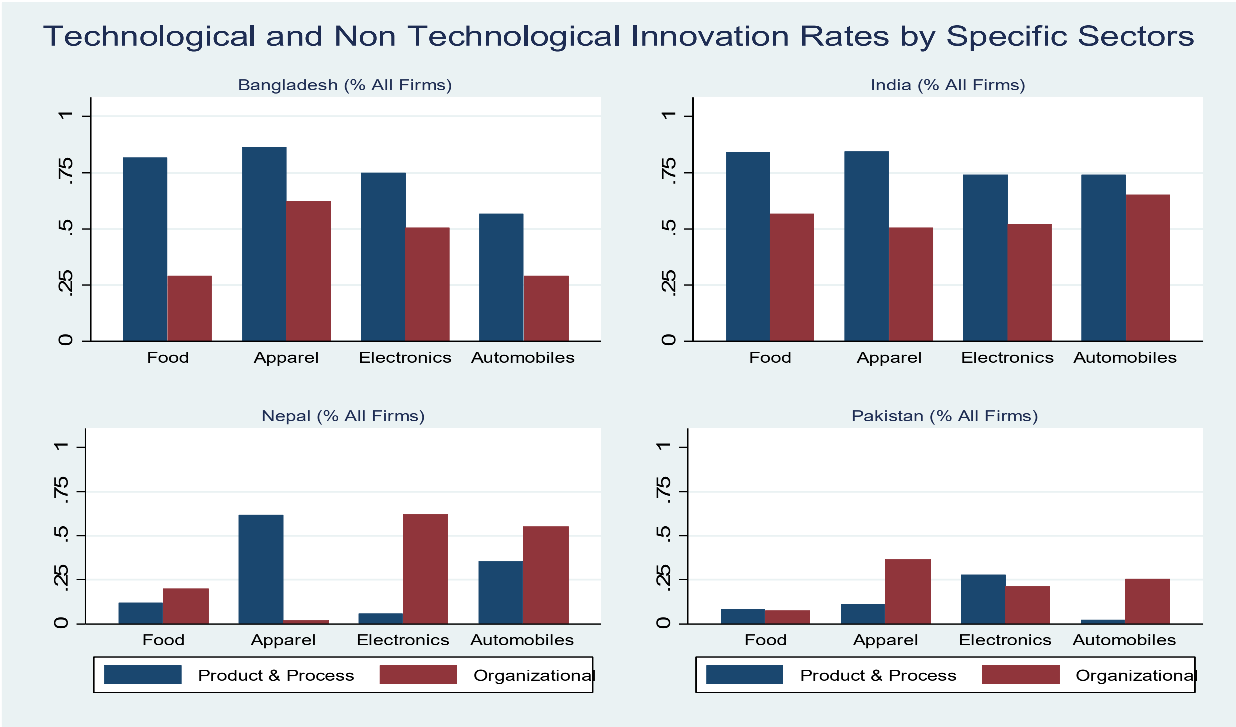
Source: Author's elaboration from Enterprise Survey (2014)

Differences across sectors: Indian and Bangladeshi firms located in the food, apparel, automobile, and electronics sectors are very innovative in terms of technological innovations compared to organizational innovations (Figures 2). The most dynamic sectors are electronics in Bangladesh and apparel in India. This contrasts with what is observed in Nepal, where the rate of firms introducing non-technological innovations is higher than the rate of firms introducing product and/or process innovations, especially in the apparel and

[8] Foreign-owned firms are those that have over 25% ownership by private foreign individuals, companies or organizations.

electronics industries. There are no innovative firms in the automobile industry in Nepal, and a small proportion of firms are innovative in Pakistan.

Figure 2. Technological and Non-Technological Innovations in Key Sectors



Source: Author's elaboration from Enterprise Survey (2014)

5.4 Degree of Innovativeness or Novelty

Although innovation rates are relatively large for some countries in the region, this does not necessarily mean that the degree of innovativeness is high. Indeed, one pattern found for several developing countries is that a limited number of firms engage in disruptive innovative activities such as introducing new products to the country or even better new products to the world, while the majority of them conduct incremental innovations or pure imitation - either by upgrading the quality of existing goods or introducing new products to the firm (Cirera and Sabetti, 2019).

When firms decide among alternative innovation choices, several factors affect this decision. The market structure is one important determinant. When product market differentiation is low and the degree of competition is high, the entrance of new firms in a market reduces incumbents' market shares by much more than in the case where products are imperfect substitutes like in the case of monopolistic or oligopolistic competition. As a result, firms escape competition by upgrading the quality of their existing goods. In other words, the marginal value of adding one extra unit of quality to an already supplied variety increases with the degree of product market competition (Cusolito, 2009).

Another determinant is access to credit. If breakthrough innovations are related to long-term investments, while incremental innovations are associated with short-term investments, then tight credit constraints can create a bias towards the latter. This is because lack of credit increases the probability that long-term investments will be interrupted by a liquidity shock. Ex-ante, the anticipation of this risk reduces firms' incentives to engage in long-term and disruptive innovative activities (Aghion et al., 2010). Further, firm productivity is also relevant, as the increased revenues obtained through increased efficiency allows the more efficient firms to overcome the large fixed cost of introducing radical innovations or adopting high-cost technologies. Additionally, multinational firms are more prone to introduce radical innovations than domestic firms or single-destination exporting firms, as they can dilute the fixed cost of innovating by supplying the same international new product in different countries (Brambilla, 2009).

Despite high average innovation rates in the region, there is little degree of novelty in innovation. This pattern is in line with the one observed in other regions such as ECA and Africa (Table 9). Bangladesh and India appear as the innovation leaders in SAR. However, most of their inventions are related to the imitation of existing products and/or processes and, therefore, the introduction of products and processes only new to the firm. At the other end, Nepal and Pakistan show very low innovation rates in general, including imitation activities. Firms in these two countries engage little in innovation activity. Therefore, while the more radical innovation behavior is low and similar across the four countries in the region, and also similar to the average in ECA and Africa, Bangladesh and India show very high imitation rates when compared to other countries within and outside the region, while Pakistan and Nepal show low innovation activity in general.

Quality upgrading or vertical innovations are the focus of firm-level innovation in South Asia. Firms in the region tend to innovate for upgrading the quality of their products; except for India, where horizontal innovations or the introduction of new products is slightly more frequent. This contrasts with other regions like ECA or Africa, where firms primarily innovate to create new goods.

Table 9. Percentage of innovativeness (% of all firms)

	Bangladesh	**Pakistan**	**India**	**Nepal**	**SAR average**	**ECA**	**Africa**
New to Firm	44%	8%	54%	12.3%	30%	18%	25%
Of which new Product	20%	38%	56%	0%	29%	74%	68%
Of which product upgrade	80%	62%	44%	100%	72%	26%	32%
Imitator(new to firm/local market)	37%	6%	47%	12%	26%	10%	20%
New to National	4%	2%	4%	0.3%	3%	6%	3%
New to International	3%	0.5%	2%	0.03%	1%	2%	2%

Source: Author's elaboration from Enterprise Survey (2014)

In all the SAR region except in Pakistan, process innovation is related to the introduction of a new method, followed by innovations in supporting activities (Table 10). However, a small proportion of process-innovating firms introduce an invention that is new to the market. Again, showing the low degree of innovativeness of SAR firms in terms of vertical innovations. The behavior of the region is similar to that of the ECA and Africa regions, although the percentage of firms introducing new processes to the market is more than triple that of the SAR region.

Table 10. Level of Innovativeness (Process) (% of all firms which have done process innovation)

	Bangladesh	**Pakistan**	**India**	**Nepal**	**SAR average**	**ECA**	**Africa**	**Russian Federation**	**Turkey**
New Process to Market	11%	20%	11%	7%	12%	40%	13%	38%	19%
Process-Method	89%	59%	85%	57%	73%	74%	73%	66%	94%
Process-Support Activity	50%	72%	65%	50%	59%	54%	61%	66%	55%
Logistics Innovation	39%	47%	64%	36%	47%	54%	63%	43%	71%

Source: Author's elaboration from Enterprise Survey (2014)

Lack of innovativeness is also reflected in the small proportion of innovating firms introducing new innovation outputs such as patents (Table 11), although regional innovation leaders present values above the average for the ECA and Africa regions. However, laggards are below international standards. Other innovation outputs such as trademarks or licensing are more important than patents for all the countries considered.

Table 11. Innovation outputs (% of innovating firms)

	Bangladesh	Pakistan	India	Nepal	SAR average	ECA	Africa
Patent	8%	2.2%	8%	1.3%	5%	2.5%	6%
Other than patents	18%	5%	32%	1.7%	14%	-	17%

Source: Author's elaboration from Enterprise Survey (2014)

Table 12. Links between innovativeness and firm characteristics

		Bangladesh	India	Nepal	Pakistan
No innovators	age	18.70	22.54	13.65	22.15
Imitators	age	18.42	20.39	18.21	34.24
radical	age	16.46	20.51	16.57	28.25
No innovators	size	162.09	95.99	12.89	168.94
Imitators	size	228.16	134.64	28.89	176.99
radical	size	183.04	144.23	25.30	434.45
No innovators	exporter	20.63%	18.93%	5.83%	19.71%
Imitators	exporter	24.73%	18.35%	7.46%	26.90%
radical	exporter	35.46%	32.11%	2.74%	0.86%
No innovators	foreign	0.78%	0.45%	0.06%	0.25%
Imitators	foreign	3.07%	0.40%	0.00%	0.00%
radical	foreign	1.00%	0.77%	5.49%	0.78%
No innovators	R&D intensity	4.44	17.43	0.31	11.45
Imitators	R&D intensity	4.94	24.22	0.43	70.08
radical	R&D intensity	11.68	31.71	2.62	214.17
No innovators	sales per worker	8.42	10.04	8.58	7.71
Imitators	sales per worker	8.58	10.13	9.03	8.87
radical	sales per worker	8.84	10.11	8.48	9.44
No innovators	value added per worker	7.90	9.09	7.96	9.09
Imitators	value added per worker	7.95	9.10	8.32	10.14
radical	value added per worker	8.11	9.31	6.97	9.44

Source: Author's elaboration from Enterprise Survey (2014)

R&D intensity is correlated with the novelty of innovation. Table 12 shows the average firm characteristic for each "novelty group": (i) non-innovators, (ii) imitators (new to the firm only), and (iii) radical innovators (new to the national or to the international market). There are two types of patterns across country groups. For leaders, radical innovators are younger, more middle or larger sized, exporters and national. For laggards, innovators tend to be relatively older, larger, non-exporters, and more likely foreign. Further, there seems to be a clear mapping from R&D intensity to more radical forms of innovation, in the sense that firms that have a higher level of R&D intensity tend to introduce more radical innovations. Third and more surprising is the fact that while innovators tend to have larger labor productivity than non-innovators, except for Nepal, there are no clear differences between more radical innovators and imitators.

5.5 Composition of the innovation portfolio

Product innovations in the South Asia region are mainly related to quality upgrading and new functions, while a small percentage of them is associated with the introduction of cheaper products (except in Pakistan) (Table 13). Indeed, more than 90 percent of the firms introducing new goods in Bangladesh, Nepal, and Pakistan increase the quality of their products. Innovations related to products that include different inputs, a new technology or design are relatively more important in countries such as Nepal and Pakistan.

Table 13. How innovative are new products? (% of product innovation firms)

Types of Innovation	Bangladesh	Pakistan	India	Nepal	ECA	Africa
New Function	63%	95%	66%	76%	67%	64%
Cheaper	40%	76%	22%	37%	-	42%
Better Quality	94%	96%	74%	99%	-	89%
Different Inputs	59%	77%	54%	70%	68%	58%
New Tech or Design	46%	75%	41%	81%	54%	54%

Source: Author's elaboration from Enterprise Survey (2014)

There is a lot of heterogeneity in the region in terms of the type of process innovation that firms conduct (Table 14). For example, in Bangladesh, most of the innovations are related to the introduction of a more efficient technology or the adaptation of a new technology; while in India, they are geared to automate manual processes or adapt a new technology. Almost 100 percent of processes innovations in Nepal are related to the adaptation of a new technology, while in Pakistan, most of them focus on the introduction of a more efficient technology.

Table 14. How innovative are new processes? (% of process innovation firms)

Types of Innovation	Bangladesh	Pakistan	India	Nepal	Africa
Automate Manual Process	77%	65%	67%	74%	67%
Adapt Used Technology	35%	64%	36%	78%	37%
Adapt New Technology	88%	72%	68%	94%	78%
More Efficient Technology	87%	89%	55%	64%	50%

Source: Author's elaboration from Enterprise Survey (2014)

Although there are several reasons why firms may decide to introduce new goods and processes, product innovations are usually conducted with three objectives: (i) extending the product portfolio, (ii) increasing the market share or introducing new markets, and (iii) escaping competition (Table 15), while process innovation are aimed at: (i) increasing the quality of existing products, and (ii) increasing production speed and scale (Table 16). The pattern is in line with what has been observed in other regions such as Africa.

Table 15. Main Reasons for Product Innovation (% of product innovation firms)

Reasons	Bangladesh	India	Nepal	Pakistan	Africa
Replace Product	63%	15%	10%	69%	34%
Extent Range	90%	94%	100%	95%	90%
New Market/Increase share	59%	91%	100%	74%	78%
Reduce costs	32%	26%	10%	50%	34%
Compete same products	83%	75%	82%	50%	68%
Comply standards	45%	48%	13%	72%	47%
Decrease in demand	69%	43%	41%	58%	51%

Source: Author's elaboration from Enterprise Survey (2014)

Table 16. Main Reasons for Process Innovation (% of process innovation firms)

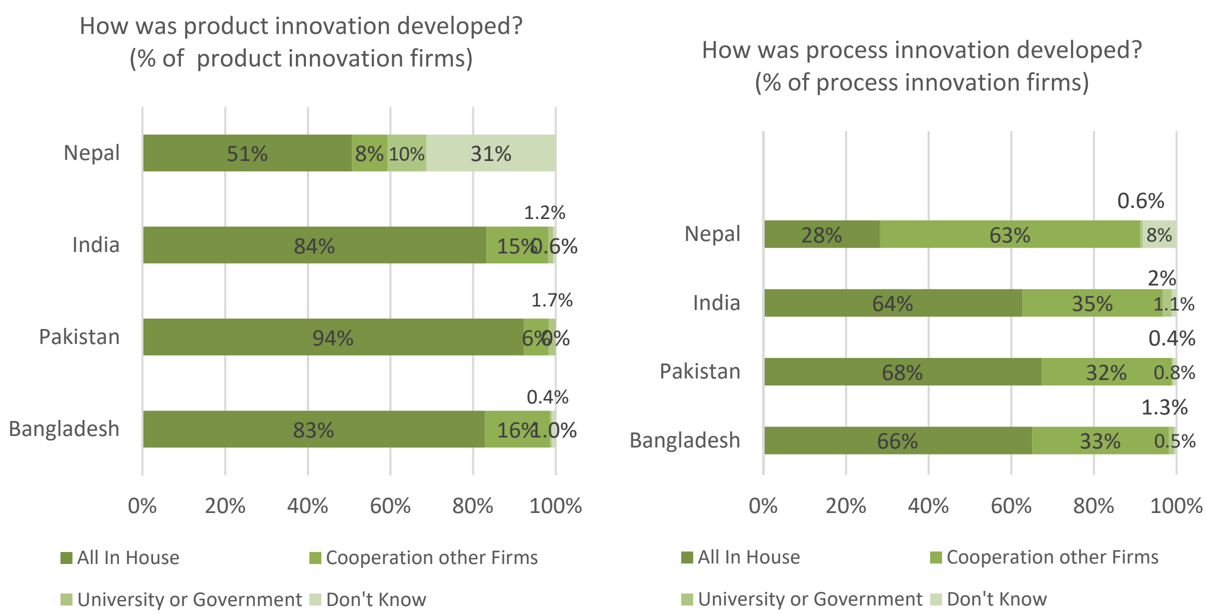
Reasons	**Bangladesh**	**India**	**Nepal**	**Pakistan**	**Africa**
Increase quality products	95%	81%	66%	92%	81%
Increase production	87%	66%	56%	63%	85%
Increase flexibility	65%	58%	65%	46%	78%
Increase speed production	89%	68%	62%	64%	78%
Increase speed delivery	60%	42%	45%	63%	71%
Decrease production costs	44%	41%	27%	41%	47%
Reduce waste	74%	54%	66%	63%	56%

Source: Author's elaboration from Enterprise Survey (2014)

5.6 Characteristics of the Innovation Process

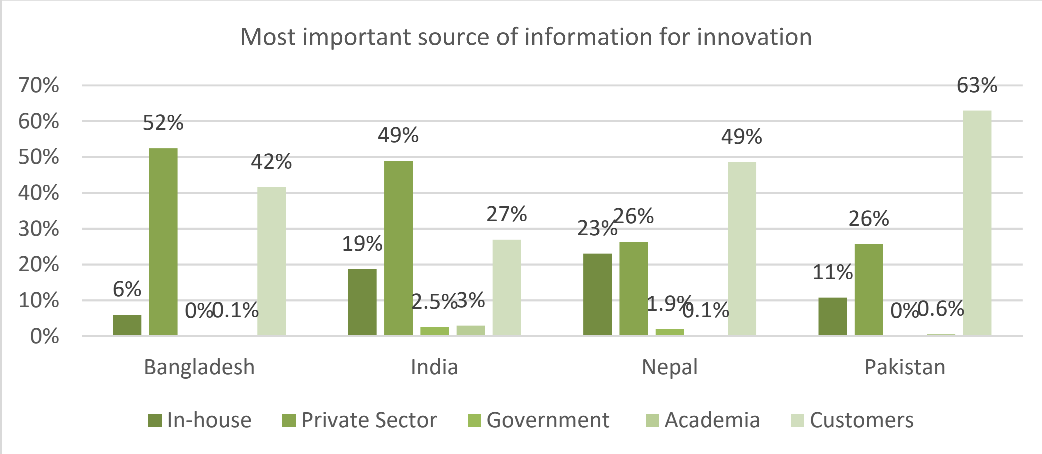
In the South Asia region, most of the product and process innovations are in-house. However, process innovations are related to more collaboration than product innovations. External cooperation is in most of the cases linked to other firms, although cooperation with the private sector plays a more important role for process innovation than for product innovation (Figure 3). The primary sources of information for leaders are in-house or the private sector, while customers dominate in laggard countries (Figure 4).

Figure 3. In-house versus Collaboration



This very high reliance on in-house innovation development - larger than in Africa and much larger than in the ECA region – significantly constrains the ability to increase the novelty of innovation either due to the lack of internal resources or the inability of exploiting synergies with the rest of the private sector or the scientific community. Reliance on internal capabilities only implies limited scope to introduce more novel products, and it is likely to influence the large imitation rates observed in India and Bangladesh.

Figure 4. Information sources for innovative firms



Source: Author's elaboration from Enterprise Survey (2014)

5.7 Innovation Patterns across Regions

It is widely recognized that innovation activity is spatially concentrated, and that R&D investments and innovations are more spatially concentrated than employment (see Carlino and Kerr, 2014 for an excellent empirical and theoretical review). In terms of outputs, the creation of new products is more spatially concentrated than the introduction of new patents (Acs et. al., 1994); while the origination of the latter tends to be concentrated in few and large cities (Forhnahl and Brenner, 2009; Bairoch, 1988, respectively). Theories explaining concentration of R&D and innovation activities allude to agglomeration advantages in three dimensions: (i) sharing of common specialized inputs and factors of production, (ii) improvement of the quality of the matching process between specialized inputs or factors of production and innovating firms, and (iii) presence of externalities such as knowledge spillovers that facilitate the flow of tacit knowledge and new ideas.

Why is innovation spatially concentrated? "Sharing" theories highlight the importance of thick local factor or input markets that allow innovating firms which are spatially concentrated in a particular location to have access and share specialized workers or inputs that are essential for innovative activities (Porter, 1990); reducing at the same time production costs (Porter, 1998). "Matching theories" rely on the argument that agglomeration is associated with thicker markets; which in turn, increases opportunities for specialized workers, reduces their waiting costs of finding the best partner, and raises the likelihood of assortative matching with positive effects in terms of innovation success. "Knowledge-spillover theories" rely on the characteristics of knowledge as a public good, that is non-rivalry and non-excludable, to emphasize the benefits of agglomeration in terms of facilitating the flow of new ideas, which are an important input for innovation.

A comparison of innovation rates by region shows a lot of variation in innovation patterns across different areas within a particular SAR country (Table 17). In Bangladesh, Dhaka and Chittagong are the most innovative regions, with rates of technological innovation near 80 percent; while Chittagong and Khulna are innovative in terms of non-technological innovations. In India, there are five regions with innovation rates above 90 percent for product and/or process innovation: Andhra Pradesh, Arunachal Pradesh et al., Bihar, Punjab, Rajasthan, and Uttaranchal; while organizational innovation rates fluctuate between 31 percent in Rajasthan and 74 percent in Andhra Pradesh. In Nepal, the West area presents the highest innovation rates for both technological and non-technological innovations; while Sindh and Punjab in Pakistan display the highest innovation rates.

Table 17. Innovation by Region (% of all firms in each category)

Country	Region	Product	Process	Product or Process	Organizational
	Dhaka	44.2%	64.4%	79.3%	21.6%
	Chittagong	43.5%	59.0%	80.9%	41.3%
	Khulna	46.1%	37.4%	66.9%	31.1%
Bangladesh	Rajshahi	41.0%	44.4%	56.3%	12.7%
	Punjab	8.8%	9.5%	16.2%	23.2%
	Sindh	14.3%	11.7%	23.3%	19.5%
	Khyber-Pakhtunkhwa	4.1%	4.7%	8.8%	0.4%
	Balochistan	0.0%	0.0%	0.0%	0.0%
Pakistan	Islamabad	1.1%	3.4%	3.4%	9.3%
	Andhra Pradesh	53.5%	77.3%	90.5%	73.8%
	Arunachal Pradesh et al	23.8%	82.1%	91.4%	38.0%
	Assam	37.4%	79.9%	88.8%	48.6%
	Bihar	68.9%	71.7%	93.9%	94.8%
	Chhatisgarh	72.8%	57.4%	89.9%	57.0%
	Delhi	48.9%	52.9%	76.9%	41.4%
	Goa	61.9%	61.0%	82.6%	24.3%
	Gujarat	33.8%	30.7%	57.8%	50.5%
	Haryana	63.5%	71.7%	88.9%	51.0%
	Himachal Pradesh	59.8%	63.2%	83.0%	53.5%
	Jammu & Kashmir	29.7%	70.2%	76.6%	72.8%
	Jharkhand	56.3%	30.7%	69.8%	87.2%
	Karnataka	74.7%	27.1%	80.8%	75.6%
	Kerala	56.6%	24.1%	68.9%	13.5%
	Madhya Pradesh	29.0%	77.5%	89.9%	65.5%
	Maharashtra	36.2%	25.7%	57.0%	61.1%
	Orissa	68.5%	54.6%	86.6%	24.1%
	Punjab	64.8%	86.0%	96.6%	68.1%
	Rajasthan	58.6%	82.2%	94.8%	31.4%
	Tamil Nadu	73.6%	27.2%	79.5%	73.8%
	Uttar Pradesh	39.3%	71.9%	84.9%	49.2%
	Uttaranchal	54.5%	73.3%	90.4%	66.0%
India	West Bengal	46.3%	66.1%	88.3%	51.4%
	West	16.3%	19.8%	32.7%	72.5%
	Central	13.2%	8.8%	21.1%	26.8%
Nepal	East	1.4%	3.2%	4.4%	44.2%

Source: Author's elaboration from Enterprise Survey (2014)

In all the SAR, large cities with more than 1 million population display a larger proportion of firms introducing new products than smaller cities (Table 18). A similar pattern is observed for process and organizational innovation except in India and Nepal. The innovation map in terms of product and organizational innovation is different from that observed in ECA, where innovation rates are higher in small cities. This contrasts the innovation picture portrayed in Africa, which presents similarities to the South Asia region.

Table 18. Innovation by City Size (% of all firms in each category)

Country	City Size	Product	Process	Product or Process	Organizational
Bangladesh	Less than 1 mm	17%	12%	24%	18%
	Over 1 mm	41%	62%	80%	24%
Pakistan	Less than 1 mm	0.2%	2%	2%	6%
	Over 1 mm	10%	10%	18%	22%
India	Less than 1 mm	51%	69%	86%	51%
	Over 1 mm	57%	52%	81%	51%
Nepal	Less than 1 mm	11%	11%	20%	59%
	Over 1 mm	14%	9%	23%	18%
ECA	Less than 1 mm	19%	12%	26%	23%
	Over 1 mm	17%	12%	24%	18%
Africa	Less than 1 mm	23%	28%	41%	32%
	Over 1 mm	32%	29%	51%	39%

Source: Author's elaboration from Enterprise Survey (2014)

In line with the behavior observed in the ECA and Africa regions, all countries of the South Asia region except Bangladesh display higher product innovation rates in main business cities compared to other cities (Table 19). By contrast, all countries except Pakistan show higher process innovation rates in other cities. Organizational innovation predominates in main business cities following international patterns.

Table 19. Innovation by Business City (% of all firms in each category)

Country	Business City	Product	Process	Product & Process	Organizational
Bangladesh	Main Business City	43%	61%	79%	26%
	Other City	45%	64%	78%	24%
Pakistan	Main Business City	8%	8%	15%	17%
	Other City	3%	2%	3%	11%
India	Main Business City	56%	59%	83%	53%
	Other City	42%	73%	87%	43%
Nepal	Main Business City	13%	10%	21%	34%
	Other City	10%	14%	21%	27%
ECA	Main Business City	23%	14%	30%	26%
	Other City	18%	12%	25%	21%
Africa	Main Business City	27%	31%	47%	39%
	Other City	22%	29%	43%	32%

Source: Author's elaboration from Enterprise Survey (2014)

Innovation activity in South Asia appears to be geographically concentrated only when considering the novelty of innovation. To explore the impact of agglomeration and following the literature, Table 20 compares employment shares across provinces with innovation activities shares and their concentration measured with the Herfindahl index. Larger concentration of innovation activities in relation to employment implies that there may be some agglomeration effects of innovation activity, as suggested in the literature. In general, however, the table shows that innovation activities tend to be less concentrated than employment, except in Pakistan, and more concentrated when considering higher degrees of innovation novelty, such as new to the national or international markets. Thus, the evidence suggests that agglomeration may matter mostly for more radical innovation rather than for imitation.

Table 20. Concentration of economic and innovative activities

	Employment share	Firms share	Innovators (product/process)	innovators product	Radical (national/ international)	R&D
Bangladesh						
Dhaka	68.17%	62.93%	62.65%	62.56%	72.00%	55.92%
Chittagong- Sylhet	27.15%	24.14%	24.77%	23.43%	13.33%	33.06%
Khulna	3.60%	7.98%	7.65%	7.97%	10.67%	6.94%
Rajshahi	1.08%	4.95%	4.93%	6.04%	4.00%	4.08%
Herfindahl concentration	0.39	0.28	0.28	0.28	0.40	0.24
India						
Andhra Pradesh	4.08%	6.27%	6.24%	6.51%	3.40%	3.18%
Arunachal Pradesh et al	0.98%	2.38%	2.53%	1.57%	0.85%	1.81%
Assam	2.58%	3.69%	4.07%	3.53%	0.28%	4.42%
Bihar	1.02%	3.01%	3.35%	2.93%	1.70%	2.80%
Chhatisgarh	2.98%	3.26%	3.50%	3.74%	0.85%	5.23%
Delhi	4.46%	5.70%	5.78%	6.02%	3.12%	7.54%
Goa	1.17%	1.35%	1.25%	1.47%	1.70%	1.25%
Gujarat	1.61%	5.01%	3.25%	2.77%	5.95%	2.87%
Haryana	7.98%	4.47%	4.82%	5.43%	9.63%	7.60%
Himachal Pradesh	2.87%	2.32%	2.25%	2.55%	2.27%	3.43%
Jammu & Kashmir	3.24%	2.26%	2.46%	1.63%	2.83%	2.68%
Jharkhand	1.90%	3.15%	2.93%	2.93%	1.13%	3.49%
Karnataka	11.12%	6.47%	6.46%	8.36%	8.78%	6.23%
Kerala	3.69%	4.93%	4.28%	5.32%	10.76%	3.12%
Madhya Pradesh	5.10%	5.07%	5.35%	3.31%	1.70%	5.23%
Maharashtra	5.41%	6.87%	5.03%	4.56%	9.63%	3.68%
Orissa	5.79%	3.38%	3.32%	3.53%	0.57%	5.23%
Punjab	8.35%	4.58%	5.39%	6.13%	11.33%	4.11%
Rajasthan	4.13%	5.13%	5.82%	4.94%	0.85%	6.67%
Tamil Nadu	3.24%	6.13%	6.03%	8.36%	13.60%	4.05%
Uttar Pradesh	5.46%	5.64%	5.82%	5.37%	4.25%	6.54%
Uttaranchal	3.83%	3.09%	3.53%	3.26%	0.28%	4.61%
West Bengal	9.01%	5.84%	6.56%	5.81%	4.53%	4.24%
Herfindahl concentration	0.0166	0.0057	0.0055	0.0089	0.0395	0.0068
Nepal						
West	11.34%	19.32%	24.14%	27.14%	14.29%	7.41%
Central	80.76%	70.06%	66.90%	62.86%	85.71%	88.89%
East	7.90%	10.62%	8.97%	10.00%	0.00%	3.70%
Herfindahl concentration	0.51	0.31	0.27	0.22	0.63	0.70
Pakistan						
Punjab	37.33%	55.32%	73.42%	79.63%	68.42%	64.15%

Sindh	54.75%	13.51%	18.99%	16.67%	31.58%	18.87%
Khyber-Pakhtunkhwa	4.70%	20.26%	3.80%	1.85%	0.00%	15.09%
Islamabad	3.22%	10.92%	3.80%	1.85%	0.00%	1.89%
Herfindahl concentration	0.26	0.17	0.44	0.55	0.42	0.29

Source: Author's elaboration from Enterprise Survey (2014)

6. Exploring the Causal Links Between Innovation and Productivity

As Paul Krugman famously claimed, "Productivity isn't everything, but in the long run it is almost everything. A country's ability to improve its standard of living over time depends almost entirely on its ability to raise its output per worker." (Krugman, 1994). Although several studies have been conducted to explore the links between innovation and productivity, most of the evidence available relies on the findings for developed countries, with little evidence for developing economies. It is therefore the objective of this section to fill this gap by focusing the analysis on the South Asia region.

6. 1 Methodology

In order to examine the empirical relationship between innovation and productivity, we follow a conceptual framework based on Figure 1, which forms the basis of the CDM model. The framework holds that firms invest in knowledge inputs that can be transformed into innovation outputs according to an innovation function. At a later stage, these innovation results impact on firm-level productivity, contingent on the capacity of firms to transform innovation outputs into improvements in product quality and efficiency.

As a result, the CDM model requires the estimation of three main components: (i) the knowledge function, which involves estimating the R&D and ICT functions, (ii) the innovation equation, and (iii) the productivity equation. When estimating these components, there are two critical choices to be made. The first is to define the scope of the knowledge inputs and innovation outputs to be included in the analysis. This is often related to the availability of data in the innovation surveys. In most of the CDM applications, data are restricted to the use of R&D for knowledge activities; for innovation outputs, either product and process innovation dummies, or the number of patents and the revenue associated to new products are used. Regarding innovation outputs, we focus on technological innovations -either product or process innovations – and look at revenue originated from product innovations, since patenting activity in the South Asian countries is minimal.

The second choice when examining these three innovation components relates to how the model is solved to produce economic estimates that can be interpreted in a causal way. A parameter of a model is causal, or structural, sometimes referred to as a deep parameter, when it untangles cause from effect, and is derived from a theoretical model where the directions governing the laws of motion are straight forward (Heckman, 2000). In contrast, in a reduced form setting, cause and effect are confounded in the presence of unobserved factors. Decisions regarding knowledge inputs and innovation outcomes can be made simultaneously and there can be feedback effects, especially between innovation outcomes and productivity in the sense that more productive firms may have an advantage to develop new products and/or processes (such feedbacks would be accounted for by including lagged terms in the other respective equation).

The endogeneity of R&D and innovation arises with the innovation and productivity equations, respectively. Dealing with endogeneity is crucial, as the significance of the effects of innovation on productivity tends to fall and lose statistical significance. To a large degree, the endogeneity in our context is likely driven by an error in variable measurement, more than a simultaneity problem, given the inherent subjective nature of the survey questions on innovation. As a result, the correlation between innovation rates and returns may typically not be suggestive of any impact. In contrast, the structural estimates address the error in variable and simultaneity issues by exploiting variation in innovation outcomes driven by exclusion restrictions or variables that are not related to productivity.

The approach in this paper is closer to the original CDM approach and uses the cmp STATA command, a Generalized Structural Equation Model (GSEM) in line with previous work by Skrondal and Rabe-Hesketh (2004). An advantage of this approach is that more information is exploited when solving the model by maximum likelihood where distributions for the random part of the model are postulated.[9] Our model is a recursive system of four blocks of equations, where each endogenous variable is determined sequentially, and can be consistently estimated by the full information maximum likelihood (FIML) SUR framework, when instrumental variables appear in the earlier equations with endogenous dependent variables. Roodman (2011) shows that the FIML SUR estimator can consistently estimate the parameters of endogenous variables, such as innovation outcomes or R&D, in mixed-process simultaneous systems that can be expressed as recursive and the endogenous variables appear on the right-hand side.

In the model, firms first decide the intensity of input choices – R&D and ICT. These input choices along with other factors feed into different types of innovation outcomes (product and/or process, or innovation sales). Finally, innovation drives productivity performance at the firm level, accounting for controls. Given the heterogeneity of innovation behavior across the countries in the region, we estimate the model country by country.

6.2 Variables and definitions

One important caveat when interpreting the model is related to the type of productivity measure that we are using for the analysis, and its implications for the interpretation of the results. The measure of productivity used is not strictly and exclusively related to firm efficient but to overall firm performance. Recent literature on productivity highlights the need of considering physical total factor productivity (TFP) and/or physical labor productivity as the true measures of firm-efficiency. However, measuring these variables is challenging because it requires to disentangle technical efficiency from other supply- and demand-side factors that affect firm sales--a variable commonly used as the numerator to calculate firm-level productivity. On the supply-side, these factors include adjustment costs and factor price distortions, which affect marginal production costs and, therefore, final product prices. On the demand-side, these factors involve mark-ups, quality upgrading, product price distortions, and changes in the product mix, which affect product prices, as suggested in the work by De Loecker (2007), Foster et al., (2008), Hsieh and Klenow, (2009), and Bernard et al. (2010).

If disaggregated data on product prices are available at the plant/firm-level, then the best measures to capture labor productivity are (i) deflated sales (output) per worker or value-added per worker and/or (ii) deflated sales (output) per hour worked or value-added per hour worked; and the best measure to capture TFP is "physical TFP", defined as the deflated value of sales (output) net of the contribution of labor and capital (it could also exclude the contribution of materials). But lack of data on prices and factors of production implies that our measure of productivity "sales per worker" should be considered not strictly related to firm efficiency but to overall firm performance.

[9] The model falls in the larger class of simultaneous-equation systems in which a narrow set is the system of seemingly unrelated equations where no endogenous regressor appears as explanatory variables in any of the equations being estimated. Simultaneous estimation is more efficient as it takes into account the full covariance structure.

Table 21 shows the definition of the variables used in the analysis. We follow Crepon et al. (1999) and Griffith et al. (2005) in selecting the main explanatory factors of the model. However, it is important to emphasize that in order to estimate and achieve convergence in the model and compare the results for the four countries we use a more parsimonious specification.

Table 21. Variables for estimating the relationship between innovation and productivity

Variables	Description
Knowledge intensity	
R&D dummy	Dummy with value 1 if firm invests in Intramural or extramural R&D
ICT Index	Composite index based on an index that measures the intensity of internet adoption and the intensity of use computer and software
Innovation outputs	
Product/process innovation	Dummy with value 1 if any new or significantly improved product, service or process introduced by this establishment in last three years.
Innovation sales	Share of sales that can be attributed to the introduction of a new or upgraded innovation.
Productivity	
Sales per worker (sales/L)	Logarithm of sales per worker
Firms' Market Condition and Access to Finance	
Working capital	Share of working capital financed by internal funds. This is a proxy to measure the degree of external financial constrain for the firm
Duopoly/monopoly	Whether firms face one or two main competitors in the market
External Market (Exporter and Importer)	Export and Import dummies
Informal Sector Competition	How much practices of informal sector are an obstacle. Index 0 not an obstacle to 4 severe obstacle.
Demand (Increasing) pull effect	Dummy indicating whether firm's demand has increased by evaluating revenue or employment growth.
Technology Push Factors	
License Foreign Technology	Dummy whether a firm use technology licensed from a foreign-owned company
New Capital in Previous Year	Dummy whether a firm has purchased any new fixed asset in the last fiscal year
Firm characteristics	
Log (K/L)	Capital intensity defined as the log of the ratio of capital to labor in the firm
Educational Obstacles	Dummy created for those which inadequately educated workforce presents major or severe obstacles
Age	Log of firms' age
Log(L) – Size	Log of employment
Agglomeration	
Spillovers	This is the share of other innovators in the same region and sector
Business city	Dummy with value 1 if location of the establishment is in the main business city
Other Controls	
Sector Dummy	Dummy based on SIC classification
Country Dummy	Dummy for each country

Estimating the first stage

To understand the determinants of knowledge inputs adoption - both R&D and ICT adoption -we focus on three sets of variables. First, we examine the role of firm characteristics, for instance, size, age, and financial constrains-measured through the share of internal sources of funding on total funds used to finance working capital-because although the main constrains for R&D and ICT adoption are often the same for different types of firms, their ability to overcome those barriers can vary significantly depending on their characteristics. Second, we look at market conditions and market structure because these factors shape firms' incentives to acquire knowledge inputs in order to innovate. Evidence about the relevance of market structure, more precisely, the degree of product market competition, on innovation has been mixed. However, there is theoretical and empirical consensus that market structure is relevant to explain innovation incentives, and that the degree of product market competition can play an important role in affecting both the magnitude and the composition of innovative activities. While early empirical evidence provided by Porter (1990), Geroski (1990), Baily and Gersbach (1995), Nickell (1996), and Blundell, Griffith and Van Reenen (1995) support the view that competitive pressures encourage innovation, more recent evidence offered by Aghion, Bloom, Blundell, Griffith, and Howitt (2005) shows that the relation is inverted U-shaped. In terms of composition, Cusolito (2009) shows that competition induces firms to specialize vertically by upgrading the quality of existing goods.

Thus, to account for those effects, we include the following variables in our specification: (i) whether competition from informal firms-is an obstacle for the firm, (ii) if the sector in which the firm- operates has a duopoly structure according to-firm's perception, and (iii) the extent of integration into international markets through trade. Third, we look at technological factors such as (i) whether the firm upgraded recently some of the working capital, and (ii) whether the firm has a license to use foreign technology, as these variables can make investments in knowledge capital more attractive.

Estimating the second stage

To estimate the likelihood of being successful in the innovation process, we use a similar set of independent variables to the ones used in the first stage. However, we exclude technological enablers as they are not independently relevant to explain innovation outcomes - and we add three new critical variables -that affect the likelihood of being successful in the innovation process. First, with the objective of accounting for the effect of complementary factors, we add the extent to which firms perceive inadequately educated workforce as an obstacle to their performance-. Second, in order to account for the impact of positive externalities coming from agglomeration and knowledge spillover effects, –we include a variable that captures urban agglomeration in main business areas, and another variable that captures the density of other innovators in the same region and sector, respectively. Third, we use R&D investments as a determinant of innovation outcomes.

Estimating the third stage

In order to estimate the productivity equation, we assume a Cobb-Douglas production function, and we allow the empirical model to determine the type of factor returns i.e., increasing, constant, or decreasing. This explains why the estimated specification includes not only capital intensity i.e., K/L but also labor as a free-standing variable. Further, we include two different types of innovation variables: (i) a dummy that takes value 1 if the firm conducted product and/or process innovation, and 0 otherwise, and (ii) the percentage of increase in sales experienced by the firm in the last three years due to product innovation. In order to explore the existence of heterogeneous effects across different types of innovations: (i) imitation, (ii) radical-national, and (iii) radical-international, we include interaction effects with two variables. The first variable takes value 1 if the innovation is new to the national market and 0 otherwise, while the second variable takes value 1 if the innovation is new to the international market and 0 otherwise.

Summarizing, the estimated model has three stages and four equations that are estimated simultaneously. The first stage estimates a model for the determinants of ICT adoption – internet, computer and software-and a Probit model for the probability of conducting R&D. The ICT index is a synthetic index constructed as an average of two sub-indices, ICT computer and software and ICT internet use. These are averages of normalized variables indicating the intensity of each type of ICT, like the percentage of workers using computers regularly or internet users.[10] In the second stage, we estimate an innovation outcomes equation using the first-stage estimated knowledge inputs and additional controls. Finally, in the last stage, we - assume a Cobb-Douglas production function and we estimate sales per worker assuming an augmented version of the production function that accounts for the effects of innovation outcomes as inputs. In what follows we show the main results from the simultaneous estimation. Regarding knowledge inputs, we focus on the R&D results, the key input for innovation.

6.3 Explaining the adoption of knowledge activities in South Asia

The most important determinant of R&D adoption for all countries in the South Asia region is firm size, indicating that larger firms are more likely to engage in R&D activities than smaller companies (Table 22). Having a license that allows a firm to use a foreign technology is an important push factor to adopt R&D in all countries but Bangladesh. Exporters in India and older firms in Pakistan are also more likely to engage in R&D activities than non-exporters and young firms, respectively. Further, financial constrains appear as an important determinant affecting negatively investments in R&D activities for all countries except Bangladesh.

Further, market structure affects R&D efforts only through informal sector competition. The negative coefficient associated with this variable shows that competition from informal firms acts as a deterrent of R&D activities in India. Models explaining the negative relationship between competition and R&D efforts at the firm-level show that laggard firms are the ones who stop investing in R&D when they are far from the technological frontier. However, this explanation does not seem to rationalize the negative coefficient in India, where formal firms are probably the leaders and informal firms the laggards. The negative effect may be capturing, however, imitation effects coming from informal companies. The other variable related to market structure, whether the firm competes in a monopolistic or oligopolistic market, does not appear as a significant determinant of R&D investments. This result can be rationalized by the fact that less than 9 percent of the firms in the sample compete in an oligopolistic or monopolistic market.

[10] For computer use, we use four variables; two indicator variables and two continuous variables (percentage of workers using a computer regularly and total cost spent on ICT consultants). Given the potential for large sector differences in these continuous variables, we re-scale the values as the ratio to the sector mean and then we normalize them by subtracting the sample mean and divide them by the standard deviation. Regarding internet use, we use seven indicators: two for communication (whether a firm uses internet for internal or external communication); two for e-commerce (buying or selling online) and three for information (management of inventory online; marketing online; and research online). In order to construct our internet index, we initially standard normalize all these dummies.

Table 22. The determinants of R&D adoption and ICT intensity

	Nepal		Bangladesh		India		Pakistan	
	R&D	ICT index	R&D	ICT index	R&D	ICT index	R&D	ICT index
Firms Size - in log	0.3303***	0.3447***	0.2848***	0.2537***	0.2251***	0.1574***	0.1784**	0.2181***
	(0.106)	(0.023)	(0.039)	(0.015)	(0.021)	(0.008)	(0.071)	(0.022)
Log Firm Age	0.2336	0.0526	0.0577	0.0212	0.0071	-0.0136	0.4247**	0.0946**
	(0.199)	(0.039)	(0.069)	(0.025)	(0.030)	(0.012)	(0.171)	(0.044)
Firm Exports	0.1673	0.1565**	-0.0011	0.3138***	0.1286**	0.1035***	0.0109	0.3080***
	(0.304)	(0.071)	(0.148)	(0.056)	(0.063)	(0.026)	(0.247)	(0.076)
Working capital	-0.0061*	0.0003	-0.0004	-0.0007	-0.0019***	-0.0002	-0.0086*	-0.0038**
	(0.004)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.005)	(0.002)
Duopoly/Monopoly	0.3389	0.2058**	-0.0602	0.2111**	0.0093	0.0299	0.0430	0.0114
	(0.493)	(0.099)	(0.245)	(0.086)	(0.080)	(0.033)	(0.253)	(0.077)
New Capital previous Year	0.3052	0.1820***	-0.0271	0.0174	0.0155	-0.0249	-0.0733	-0.0764*
	(0.230)	(0.050)	(0.098)	(0.046)	(0.050)	(0.018)	(0.226)	(0.045)
Informal Sector as Obstacle	0.1104	0.0448	-0.2199	-0.0557	-0.2187***	-0.0074	-0.0860	0.0814
	(0.269)	(0.041)	(0.181)	(0.065)	(0.070)	(0.013)	(0.299)	(0.058)
License_foreign	1.9250***	-0.1022	-0.1771	0.1327***	0.1884**	0.0277	0.8201***	-0.0831*
	(0.462)	(0.135)	(0.147)	(0.051)	(0.087)	(0.029)	(0.249)	(0.049)
Constant	-2.9221***	-1.4913***	-1.6676***	-1.3925***	-1.3279***	-0.5659***	-1.3310	-0.6241*
	(0.620)	(0.499)	(0.297)	(0.108)	(0.149)	(0.060)	(0.941)	(0.353)
Observations	470	470	990	990	3,481	3,481	499	499
Sector dummies	ISIC-1digit	ISIC-1digit	ISIC-2digit	ISIC-2digit	ISIC-2digit	ISIC-2digit	ISIC-1digit	ISIC-1digit

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 23. The determinants of innovation

	Nepal		Bangladesh		India		Pakistan	
	Technol. innovation	innovation sales	Technol. innovation	innovation sales	Technol. innovation	innovation sales	Technol. innovation	innovation sales
Firms Size - in log	-0.5037***	-0.0190	0.2318	0.0055	0.2800***	-0.0504***	0.3496***	0.0124
	(0.118)	(0.035)	(0.228)	(0.054)	(0.028)	(0.016)	(0.048)	(0.010)
Invests in R&D	0.2946	0.1817***	-1.1062***	0.4595***	-1.8674***	0.1978**	0.1914	0.0924***
	(0.375)	(0.025)	(0.339)	(0.033)	(0.066)	(0.096)	(0.451)	(0.035)
ICT Index	1.9345***	0.0497	-0.5478	-0.1465	0.2354	0.1908***	-1.5988***	-0.0468
	(0.197)	(0.096)	(0.911)	(0.203)	(0.239)	(0.062)	(0.122)	(0.043)
Log Firm Age	-0.1699*	-0.0126	0.0246	-0.0085	-0.0697	-0.0088	0.2090**	0.0152
	(0.089)	(0.010)	(0.063)	(0.015)	(0.043)	(0.006)	(0.085)	(0.011)
Education as Obstacle	-0.0404	-0.0280*	0.2207*	-0.0045	-0.0412	-0.0218*	-0.1052	-0.0310**
	(0.117)	(0.016)	(0.124)	(0.022)	(0.041)	(0.013)	(0.109)	(0.015)
Firm Exports	-0.4398***	-0.0475*	0.3432	-0.0309	0.1827***	0.0290*	0.4155***	-0.0076
	(0.151)	(0.027)	(0.288)	(0.076)	(0.053)	(0.016)	(0.159)	(0.021)
Demand Pull Effect	-0.0611	-0.0173	0.1592*	-0.0526***	0.0376	0.0220**	0.0413	0.0264**
	(0.098)	(0.015)	(0.095)	(0.019)	(0.037)	(0.010)	(0.061)	(0.013)
workcap	-0.0005	-0.0001	-0.0017	0.0008**	-0.0005	-0.0001	-0.0059*	-0.0001
	(0.002)	(0.000)	(0.001)	(0.000)	(0.001)	(0.000)	(0.003)	(0.000)
duo_mono	-0.1417	0.0355	-0.2531	0.0467	0.0796	0.0133	-0.0351	0.0061
	(0.226)	(0.030)	(0.350)	(0.069)	(0.065)	(0.015)	(0.140)	(0.017)
business	-0.2419**	-0.0294*	-0.0306	0.0253	0.0177	0.0020	0.1533	0.0204
	(0.118)	(0.017)	(0.097)	(0.020)	(0.023)	(0.010)	(0.154)	(0.022)
spillover	-2.8679	-0.1570	2.4450*	-0.7407***	8.4422	3.1811**	1.5389	0.3170
	(1.877)	(0.274)	(1.482)	(0.284)	(7.763)	(1.536)	(1.258)	(0.205)
Constant	2.2236***	0.1590	-0.3917	-0.0933	-0.8571***	0.2784***	-1.7833***	-0.0998
	(0.433)	(0.189)	(1.426)	(0.296)	(0.241)	(0.063)	(0.569)	(0.087)
Observations	470	470	990	990	3,481	3,480	499	502
Sector dummies	ISIC-1digit	ISIC-1digit	ISIC-2digit	ISIC-2digit	ISIC-2digit	ISIC-2digit	ISIC-1digit	ISIC-1digit

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

6.4 Innovation determinants in South Asia

There is large heterogeneity regarding the factors affecting the success of introducing technological innovations –either product and/or process innovations-across countries in the South Asia region. Indeed, no variable considered as an innovation determinant, except R&D, is statistically significant across all countries. Table 23 shows the results of estimating the second stage. Odd columns show the estimates for the Probit specification (e.g., discrete dependent variable), while even columns display the results for the turnover associated with product innovation (e.g., continuous dependent variable or innovation intensity).

R&D is an important determinant of the intensity of innovation, but not of the probability of adopting a technological innovation. Regarding the main variables of interest, knowledge inputs, R&D plays a critical role on the intensity of innovation. However, a more puzzling result is the fact that R&D adoption appears to be negatively correlated with technological innovation in Bangladesh and India. This may be explained by the very large amount of imitation observed in the sample and the fact that R&D efforts may not be needed in case of very incremental innovation.

ICT appear as an enabler of innovation in India and Nepal. The impact of ICT is only important for innovation intensity in India and the adoption of technological innovations in Nepal, but not is the cases of Pakistan and Bangladesh. Therefore, we find some evidence that at least in two of the four countries ICT use – computer, software and internet – play a role as an innovation enabler in a similar way to the evidence found for some European countries (Polder et al., 2014).

Findings associated with firm characteristics show that larger firms are more likely to introduce technological innovations in India and Pakistan and less likely in Nepal; while firm size does not appear to explain gains in sales due to product innovation, with the exception of India, where larger firms surprisingly display a poorer performance than smaller firms. Further, younger firms in Pakistan are more likely of being successful in introducing technological innovations than older firms, but the reverse effect is observed in Nepal. Integration into the international trading system affects firms in opposite directions. While the effect is positive in India and Pakistan for our discrete innovation variable, it is negative in Nepal.

Lack of complementary factors such as skilled labor affect negatively the innovation intensity, although marginally, in all countries except Bangladesh. However, other constrains such as those related to access to external sources of funding play no significant role. Knowledge spillovers have a positive effect on innovation-induced turnover for leaders, but they are insignificant for laggards. Further, agglomeration or urbanization effects captured by being in a business city is not an important determinant of innovation, with most of the innovation activity occurring outside business cities in Nepal. Demand pull factors, which reflect consumers' willingness to pay a higher price for a constant quantity, are important in explaining innovation-induced sales gains in India, Pakistan and Bangladesh. Although in the latter case, the coefficient is negative, suggesting that firms in Bangladesh that supply more preferred goods have less incentives to introduce technological innovations.

6.5 Innovation and productivity in South Asia

Innovation matters for productivity, as evidence shows that technological innovations increase firm performance in the South Asia region. Tables 24 to 26 show individual country estimates of the impact of innovation on productivity. The last stage was not estimated for Pakistan due to sample constrains related to the availability of data on capital for only 120 firms. Specification (1) in each table shows the impact of being successful in introducing a technological innovation. The coefficients for Nepal and Bangladesh are positive, statistically significant, and larger than for OECD countries. In the case of India, the coefficient is positive but not statistically significant. Results for innovation-induced sales are mixed. While in the case of India, the coefficient is positive and statistically significant, the results are not significant for Nepal, and show a negative sign for Bangladesh.

Finally, one additional important finding is that the degree of novelty does not introduce any additional effect on productivity, and the returns are the same as for imitation. Thus, the evidence suggests that there are positive returns to imitation in South Asia, mostly coming from very incremental innovations in Bangladesh and India. But radical innovations do not increase firm performance above what imitation can make a firm gain. The results discussed so far are robust to alternative methodologies.[11]

Table 24 Innovation and productivity estimates in Nepal

	(1)	(2)	(3)	(4)
Log(L)	0.3769***	0.3586***	0.5314***	0.5333***
	(0.065)	(0.065)	(0.054)	(0.054)
Log(K/L)	0.2369***	0.2421***	0.1816***	0.1816***
	(0.045)	(0.046)	(0.045)	(0.045)
Prod &/or process	1.3959***	1.5707***		
	(0.339)	(0.297)		
Prod&proc*national		0.2742		
		(0.260)		
Prod&proc*inter national		0.4718		
		(0.721)		
innovation_sales			2.4410	2.4023
			(2.617)	(2.645)
Sales*national				-0.4030
				(1.148)
Constant	8.8550***	8.8240***	9.2470***	9.2436***
	(1.257)	(1.336)	(1.213)	(1.210)
Observations	470	470	470	470

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

[11] Given the fact that the GSEM methodology is more robust with large samples and well specified models, we also estimate the same models using three-stage least squares (3sls). One disadvantage of this methodology is that it uses the sample of the stage with lower number of estimates and also does not allow for a mixed process, since all the stages have to be estimated linearly. On the other hand, one advantage is that it is computationally less demanding than FIML and still addresses the issue of endogeneity instrumenting at each stage. The results for the returns to innovation, although larger in size to GSEM, are identical in terms of statistical significance.

Table 25. Innovation and productivity in Bangladesh

	(5)	(6)	(7)	(8)
Log(L)	0.1429***	0.1416***	0.1357***	0.1359***
	(0.027)	(0.028)	(0.029)	(0.029)
Log(K/L)	0.2827***	0.3006***	0.2761***	0.2764***
	(0.029)	(0.030)	(0.029)	(0.029)
Prod &/or process	0.5544*	0.6902**		
	(0.319)	(0.341)		
Prod&proc*national		0.0094		
		(0.162)		
Prod&proc*inter national		-0.0103		
		(0.171)		
innovation_sales			-1.9082***	-1.8851***
			(0.465)	(0.466)
Sales*national				-0.1514
				(0.365)
sales_int				-0.2247
				(0.509)
Constant	8.7193***	8.3993***	9.4665***	9.4639***
	(0.502)	(0.524)	(0.455)	(0.455)
Observations	990	990	990	990
Sector dummies	2 digit ISIC	2 digit ISIC	2 digit ISIC	2 digit ISIC

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 26. Innovation and productivity in India

	(1)	(2)	(3)	(4)	(5)	(6)
Log(L)	0.1379***	0.1401***	0.0886***	0.0901***	0.1266***	0.1279***
	(0.017)	(0.017)	(0.020)	(0.020)	(0.019)	(0.020)
Log(K/L)	0.1498***	0.1655***	0.1567***	0.1567***	0.1498***	0.1490***
	(0.015)	(0.016)	(0.015)	(0.015)	(0.015)	(0.015)
Prod &/or process	0.1567	0.2643				
	(0.238)	(0.233)				
Prod&proc*national		-0.0314				
		(0.068)				
Prod&proc*inter national		-0.2090**				
		(0.087)				
innovation_sales					2.8424***	2.9286***
					(0.576)	(0.578)
Sales*national						-0.1832
						(0.185)
sales_int						-0.3357
						(0.245)
Product innovation			1.2050***	1.2146***		
			(0.162)	(0.162)		
Process innovation			0.9759***	0.9739***		
			(0.166)	(0.167)		
Product*national				0.0233		
				(0.086)		
Product*intl				-0.0972		
				(0.103)		
Process*national				-0.0273		
				(0.089)		
Process*international				-0.1172		
				(0.128)		
Constant	11.5334***	11.2737***	10.7698***	10.7665***	11.2864***	11.2862***
	(0.289)	(0.294)	(0.238)	(0.238)	(0.240)	(0.240)
Observations	3,481	3,484	3,481	3,481	3,480	3,480

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

7. Conclusions

This paper describes and benchmarks innovation activities for a sample of countries in the South Asia region, as well as the impact of these activities on firm-level productivity. Overall, the evidence compiled in this paper suggests that countries in the South Asia region can be divided into two groups, both in terms of the magnitude and composition of the innovation activities: leaders (Bangladesh and India) and laggards (Nepal and Pakistan). Leaders present higher rates of innovation activities than laggards and focus more on process innovation than product innovation. Also, differences across-firms within all countries tend to present similar patterns when considering both leaders and laggards; with the acquisition of knowledge capital (e.g., R&D, investments in equipment, training) highly concentrated in few firms, and mature, exporter, and foreign-owned firms as the most innovative of the region.

Despite the high innovation rates observed for leaders, their innovations show little degree of novelty or innovativeness, as most of them are associated with the imitation of existing products and/or processes and, therefore, the introduction of products and processes that are new only to the firm. Quality upgrading or vertical innovations are the focus of firm-level innovation in South Asia. Most of the firms in the region tend to innovate for upgrading the quality of their products; except for those located in India, where horizontal innovations or the introduction of new products is slightly more frequent. Further, there are agglomeration effects, as large cities-those characterized by more than 1 million population-display a larger proportion of innovative firms in the region.

Finally, evidence on the links between innovation and productivity shows that innovation matters for firm performance. However, most of the gains are obtained through incremental innovations, which are related to the imitation of existing products/processes. Also, it is important to stress that at least for Nepal and India ICT has a positive impact on productivity acting as an innovation enabler.

The policy implications of these findings are important since the results suggest that different approaches to innovation policy are needed across the two groups of countries. For leaders, the critical challenge is how to improve the novelty and radicalness of their innovations. Here, a focus on enhancing complementary factors - skills and finance – but more importantly breaking the nature of inward innovation development by supporting cooperation with other firms and institutions is warranted. On the other hand, for laggards the policy focus needs to concentrate on increasing the number of firms doing any incremental innovation.

To conclude, it is important to emphasize that similarly to the findings for OECD countries, the results support the important role that innovation has for productivity growth, especially in India.

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