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Perspective of Innovation in Developing Countries: A Study of Economic Transition

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ABSTRACT

The paper describes firm innovation in developing countries and pro- vides a resolution to the innovation paradox. The analysis shows that firms report innovation across the income spectrum and in all sectors, but that innovation often consists of marginal improvements in process or products, rather than significant technology adoption or new product imitation, and it very infrequently involves frontier research. The coexistence of the extraordinarily low levels of innovation-related investment in poor countries with the dramatically high returns thought to accompany technological adoption and Schumpeterian catch-up, particularly far from the frontier, define the innovation paradox.

To conclude, the study shows that the low innovation activity observed in developing countries is not due to some irrationality on the part of firms and governments. Nor is it simply a question of remedying the commonly articulated knowledge-related market failures. Rather, innovation in the developing world faces barriers that are orders of magnitude more challenging than those found in the advanced world. Thus, fostering innovation requires a rethinking of innovation policies.

Keywords: Innovation, Innovation Paradox, Technology Adoption, Innovation Policies.

INTRODUCTION:

How frequently do firms in developing countries innovate, and what types of innovation do they undertake? The literature on the advanced countries is extensive, especially around the topics of investment in research and development (R&D) and patenting. However, to date, the information on developing countries, both how much they innovate and the nature of that innovation, has been scarce.

What Is Innovation?

Innovation has recently emerged as central to debates around how to rekindle productivity growth in both advanced and less advanced countries. Roughly, half of cross-country differences in income per capita across countries are thought to be due to differences in total factor productivity (TFP) (Klenow and Rodriguez-Clare 1997; Hall and Jones 1999; Jones 2016). In turn, although better allocation of factors of production emerges as an important factor in productivity growth (Hsieh and Klenow 2009; Restuccia and Rogerson 2008), a potentially larger contribution arises from improved efficiency and product quality within firms and among newly entering firms (see, for example, Collard-Wexler and De Loeker 2014 and Restuccia 2016). These gains reflect innovation in production technique, product design, and to some extent branding, all of which are driven by the ability to create, manage, and leverage new ideas.

To date, we have had only limited information on the nature of innovation activities in developing countries, on how countries develop the capacity to innovate, how it evolves over time, and what the potential barriers to innovation are. Most work on innovation has been done through the advanced country lens, and innovation is commonly seen as the work of highly educated labor in R&D–intensive companies with strong ties to the scientific community. It has, therefore, been largely perceived as a "first world" activity.

However, innovation also includes attempts to try out new or improved products or processes, or experiment with alternate ways to do things (Bell and Pavitt 1993; Kline and Rosenberg 1986). Further, the notion of Schumpeterian catch-up is precisely one of technology adoption, imitation, and adaptation of existing non-frontier technologies (Comin et al. 2008; Klinger and Lederman 2006), where firms adopt incremental (as opposed to radical) changes (Fagerberg, Srholec, and Verspagen 2010). It is also a process that requires the combination of different innovation inputs and outputs, such as product and processes, marketing or organizational innovations (Bell and Pavitt 1993).

This extended conception of innovation is captured in figure 1.1; a broad set of tangible and intangible assets with embedded knowledge, ranging from basic human and organizational capital to R&D, need to be accumulated and combined to yield innovation outcomes in the form of new or improved products and services, production and delivery processes, business organization, and patented intellectual property. These, in turn, can lead to greater productivity and associated social benefits such as better jobs, firm growth, and diversification.

Characterizing Innovation in Developing Countries: Some Stylized Facts:

Generating measures of firm-level innovation has been difficult, especially for developing countries, because of the lack of comparable information. In this section, we draw on several new sources of data, the World Bank Enterprise Surveys (ES), Bureau van Dijk (BvD) Orbis, and the World Management Survey to characterize the nature of innovation in these countries and how it evolves across the development process.

Innovation Outputs:

Although we have data only on a few dimensions on the elements in the center of figure 1.1—product and process innovation, improved organization, and intellectual property creation—the description of the data is nonetheless revealing.

Product and Process Innovation:

Figure 1.2 combines the two main innovation datasets for developing and developed economies; the United Nations Educational, Scientific, and Cultural Organization (UNESCO) data (blue dots) and the ES (green dots) to plot the share of manufacturing firms that report introducing either process or product innovation against national income.

What is immediately clear is that firms in poor countries report substantial innovative activities using both surveys. Further, figure 1.3 shows that this is broadly true across sectors. The Enterprise Surveys suggest that professional services and manufacturing have the highest innovation rates (between 50 and 60 percent of firms reporting either product or process innovation), compared to about 24 percent in construction, 30 percent in hotels, 36 percent in transport, and 25 percent in wholesale and retail. However, the broader point remains that reported innovation is widespread throughout the economy, and hence policy should not restrict itself a priori to one sector.

Is There a U-Shaped Curve in Innovation or a Measurement Problem?

The U-shaped curve shown in figure 1.2 is somewhat surprising: very poor countries report higher levels of innovation than, for instance, China, Colombia, or South Africa; and the slope increases again as countries approach the technological frontier. The high level of variance among the low-income countries and often disparate values from different surveys for the same country point to significant measurement issues. For example, the ES reports that 80 percent of manufacturing firms in India innovate, whereas the UNESCO data report only 20 percent. The overall correlation between the two sources is only. 28, with the ES consistently showing higher values. This suggests that, because the ES comprises the bulk of the low-income sample, the U-shaped relationship is exaggerated. That said, some double-sampled countries, such as Kenya or Serbia, emerge with confirmed values higher than many Organisation for Economic Co-operation and Development (OECD) (2017). countries. Further, the U shape would emerge with either data set alone.

Further, this intuition is further supported by examining some subcategories where innovations are more tightly and clearly defined, thereby allowing less discretion in response. Figure 1.4 suggests that the U pattern shown above is a survey response issue. For countries with a gross domestic product (GDP) per capita below US$40,000, the ES distinguishes between more radical product innovation, or products new to the country or

the world, and simple adoption/imitation of existing products or processes,
Any innovation which is less precisely defined. We see that high scoring and poor countries again impart something of a bowl shape to the overall relationship between innovation and income level (figure 1.4). However, the dark blue line showing the share of firms undertaking more radical product innovation increases with income, from roughly 3 to 10 percent.

Intellectual Property and Patenting:
Creating codified intellectual property is another innovation output (see again figure 1.1) and offers an even more precise measure of innovative activity. Though patenting activity very incompletely captures the universe of relevant activity (see for example Moser 2013), patent applications in the U.S. Patent and Trademark Office (USPTO) or European Patent Office do provide a more standardized measure of a particular type of knowledge output. Hence, the patterns shown in patent data are more reliable than the indicators discussed above for broader classes of innovation, though they are perhaps less relevant for developing countries.
The firm-level data from BvD Orbis enable us to disaggregate patenting activity into incidence (share of firms that patent) and intensity (patents per patenting firm). Although the Orbis data may not be collected in a fully uniform way across countries, figure 2.5 suggests some rough stylized facts.

Log (GDP per capita):
First, as expected, in most developing countries, with the plausible exception of China, well below 5 percent of firms do any patenting; however, this ramps up as we approach the technological frontier, most dramatically in Japan and Germany where over 40 percent of firms in the sample report patenting. This finding is consistent with figure 1.4 above showing that a similarly low share of firms introduces any radically new products or processes. Even Australia, Singapore, and the United States appear in this data to have relatively few firms patenting.
It is also the case, however, that firms engaging in patenting increase the number of patents filed for across the development process. Again, for most countries up to the income level of Greece or Italy, the very few firms that patent, file for relatively few patents. Though the Orbis data cannot be taken as representative of the overall firm population, they do confirm the sharply increasing share of patents per inhabitant over the development process found using USPTO data (figure 1.5) and suggest it results from both incidence and intensity increasing. The data also confirm that more sophisticated innovation activities increase as well and that relatively few firms in lowerincome countries engage in radical innovation, either by introducing new processes or products or by actually patenting.

Innovation Inputs:
Figure 1.1 reflects a wide range of inputs into the innovation process, ranging from basic organizational capacity to R&D. Data limitations force us to focus on a narrow subset of these that have been collected on a consistent cross-country basis.

R&D:
R&D spending is the most commonly discussed input into innovation, largely because it is one of the very few inputs measured with consistency across firms and countries. R&D is thought to facilitate both advances at the technological frontier and catch-up through building absorptive capacity (see, for instance, Cohen and Levinthal 1990) and most studies find it robustly related to innovation. Analysis with the ES data confirms this: R&D is an input into product and process innovation measured either by whether the country does R&D or by overall intensity. Cirera (2017) attempts to control more directly for causality and finds R&D significantly related to product innovation in particular.
Furthermore, numerous authors (Hausman, Hall, and Griliches 1984; Hall, Griliches, and Hausman 1986; Blundell, Griffith, and Van Reenen 1995; Blundell, Griffith, and Windmeijer 2002; Kortum and Lerner 2000) establish the existence of a knowledge production function at the micro level relating R&D and patenting activity. At the national level, Bosch, Lederman, and Maloney (2005) show that patenting increases with development and that an analogous aggregate global knowledge function exists (see figure 1.6).
The intensity of R&D in these countries is very low. The rise in national R&D intensity across figure 1.7 is largely driven by an increase in spending among firms doing R&D, which shows effectively a quintupling across the income span.

Technology Licensing:
Licensing is another important input into innovation activities, although to date the returns to such investments have not been estimated. ES data suggest that, even among relatively advanced countries like the Czech Republic, Israel, and Turkey, only 20 percent of firms engage in licensing (figure 1.8). Note, however, that licensing captures only the small segment of technological adoption from abroad where royalties are paid for the use of intellectual property. This share increases with development; hence, licensing appears complementary to the home country production of intellectual property (patenting).

Purchases of Equipment and Training:
The purchase of equipment is one important form of absorbing (embedded knowledge) and thereby generating productivity catch-up or "off-the-frontier" innovation. For example, more than 75 percent of Turkish firms indicate that the purchase of machinery and equipment is their main mechanism for knowledge acquisition, as opposed to other possible sources of knowledge (World Bank 2005).

Management Quality:
The final category in figure 1.1 is investment in organizational/ managerial capital. Bloom et al. (2014) argue that differing management practices contribute roughly 25 percent of the observed differences in productivity between countries and between firms in the United States.
The new availability of data has raised the profile of this issue in the economics profession, although the National Innovation System literature has long argued that managerial and organization competencies are critical inputs for innovation. For example, one reason why firms don't do more R&D or licensing may be that they lack managers with the ability to identify high-return potential projects, engage in the long-term planning required for their gestation, and then recruit, train, and motivate the talent to implement them. However, what is clear from figure 1.9 is that the quality of managerial practices is much higher in advanced countries than in developing countries.

THE CONTINUING CHALLENGE OF INNOVATION AND CAPABILITY BUILDING IN DEVELOPING COUNTRIES:

The adoption of new processes and products by firms constitutes a central dimension of productivity growth and hence of economic development. The fruits of innovation— Mokyr's (2002) "Gifts of Athena"— have powered the advanced countries to levels of prosperity unimaginable even a century ago. And, as Schumpeter noted, the ability of lagging countries to tap into a now massive stock of global know-how and technical knowledge—to be able to adopt what has already been invented—is a potential transfer of wealth from rich to poor of historic proportions.
Yet relatively few developing countries have proven able to leverage this stock of knowledge to achieve sustained catch-up with advanced countries. This report begins by offering novel and detailed evidence on innovation patterns across developing countries. Although many firms report innovating in some way, more standardized measures, such as novel innovations and licensing or research and development (R&D), suggest very little is done by poor countries. These low rates of technological adoption represent a missed opportunity for reducing global poverty and inequality of equally historic proportions. Indeed, the apparent reluctance of firms and govern- ments to pursue these opportunities in an aggressive and sustained manner poses an "innovation paradox": low investment in projects that by some measures would yield returns exceeding any other investment that poor countries could consider.
The report argues that this is not due to some irrationality on the part of developing country firms and governments. Nor is it simply a question of remedying the commonly articulated knowledge-related market failures. Rather, innovation in the developing world faces barriers that are orders of magnitude more challenging than those found in the advanced world along three key dimensions.
First, the dimensionality of the innovation problem is much greater. The advanced country literature can focus on appropriation externalities and other market failures affecting the accumulation of knowledge as a justification for a relatively narrow set of interventions because it can assume that most other markets function well and the necessary complementary factors are available. This is emphatically not the case in developing countries, which implies that the scope of the National Innovation System that policy makers must keep in their heads is much larger than in advanced countries and must include everything that affects the accumulation of all types of capital — physical, human, and knowledge assets — such as the business climate, the trade regime, labor regulations, tax regimes, or macroeconomic volatility.

It also implies that what looks like an innovation problem, such as a low rate of investment in R&D, may not be so, but rather reflect barriers to accumulating other factors, including physical and human capital. A firm may not invest in R&D because it is unable to import or finance the necessary machinery or to staff the project with the right technicians. Either shortage will depress the return on investment in R&D and thus validate the low rates of investment we see. Therefore, in determining the appropriate rate of innovation activities for an economy, it is important to consider the avail- ability of other types of capital and complementary factors. For example, the common comparisons of gross domestic expenditure on R&D, under the assumption that more is better, are not justified.

Second, firm capabilities ranging from basic managerial skills to engineering capacity constitute a key missing complementary factor. They are critical ingredients of the absorptive capacity needed to facilitate technological adoption and to manage more complex innovation and R&D. The report shows that basic firm capabilities, too, diminish with distance from the frontier; hence, constructing the entire capabilities escalator is a central goal of developing country innovation policy. As the cover painting by Remedios Varo "The Creation of Birds" captures, metaphorically we need to teach firms how to fly. As we show, interventions in this realm are a standard part of the policy tool kit in the advanced world, and the upgrading of firm capabilities is the central ingredient of the Asian miracle in many narratives.

Third, weak capabilities on the government side compound the difficulties involved in constructing a functional National Innovation System (NIS) and building private sector capability. That is, the complexity and depth of the problems involved in innovation are greater in developing countries, while government capabilities to manage them are weaker. Innovation policy thus requires an honest balancing of capabilities with tasks, which demands working on a selective set of issues at a given moment rather than trying to import a full set of institutions and policies. More important, the common policy bias toward focusing mostly or exclusively on supporting R&D in low- and middle-income countries is likely to be misplaced. R&D is an important input for innovation, but it requires a set of capabilities that are unlikely to be met by many firms in developing countries. The report attempts to take a systematic look at how policy should be formulated across the different stages of the capabilities escalator.

To this end, it also, implicitly, makes a plea for more accurate measurement to help policy makers understand innovation in their economies and better benchmark performance of firms and the NIS. The analytical work here brings to light important shortcomings in the way statistical agencies are collecting and interpreting data. The lack of consistency in how firms interpret product and process innovation leads to poorer countries often appearing to be more innovative than more advanced countries, when other measures, such as the low productivity growth associated with innovation, suggest that the measurement of innovation needs to be revisited regarding both survey design and implementation. In addition, although the World Management Survey employed here has been central to generating comparisons of capabilities across countries, we lack measures of higher-order technological capabilities. Even basic measures, such as presence of engineers in firms, are scarce, let alone measures of practices that support more sophisticated innovation.

CONCLUSION:

The literature is clear that innovation, thought of as both the transfer of existing technologies and products and the invention of new ones, is fundamental for growth and economic development.

Three points merit highlighting in addition to the patterns discussed above.

First, across the income spectrum and in all sectors, firms report innovating. However, that innovation often consists of marginal improvements in process or products, rather than significant technology adoption or new product imitation and very infrequently involves frontier research. It is clear, therefore, that the policy model appropriate for developing countries will differ from that of advanced countries. This topic will be taken up in Part II of the report.

Second, investments in innovation-related inputs increase together with income per capita. This is suggestive of a high degree of complementarity among these "factors of production:" If a firm (country) is going to invest more in innovation, they are likely to need to invest in machines, trained people, and new organizational techniques as well.

Third, that these investments rise together with development, and the fact that in developing countries only a small fraction of firms undertake significant investments in serious product or process upgrading, technology licensing, managerial practices, or R&D, may seem somehow reasonable, but upon reflection, it is not obviously so.

The coexistence of the extraordinarily low levels of innovation related investment in poor countries with the dramatically high returns thought to accompany technological adoption and Schumpeterian catch-up, particularly far from the frontier, poses a true "innovation paradox."

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Figure 1.1 Innovation Inputs and Knowledge Activities

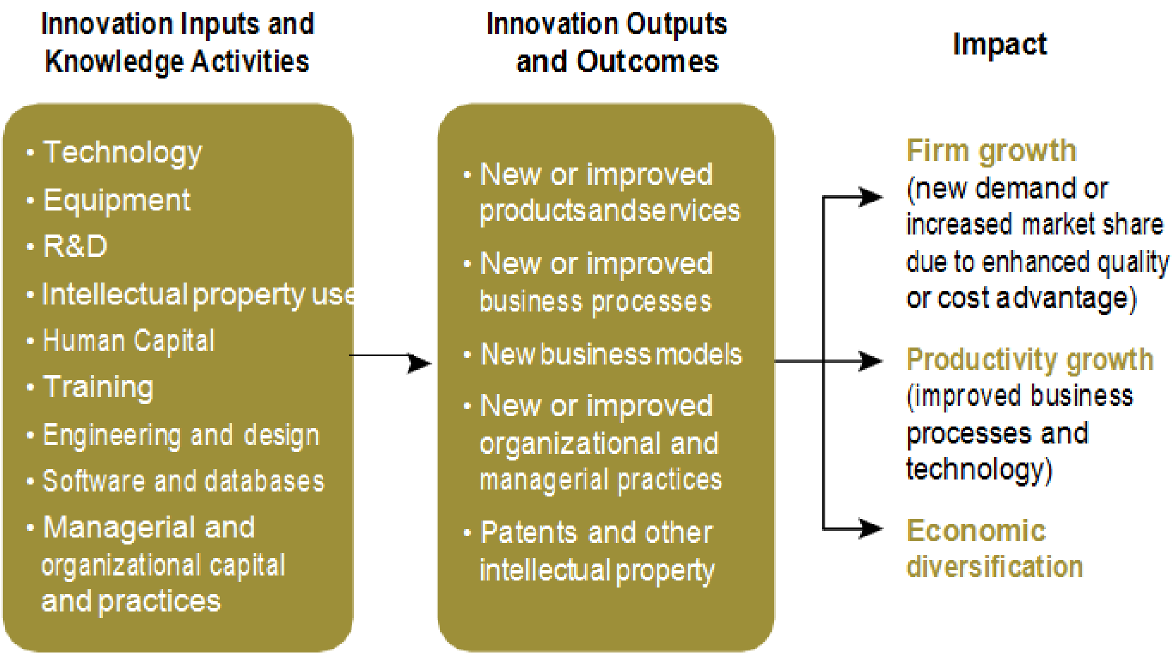

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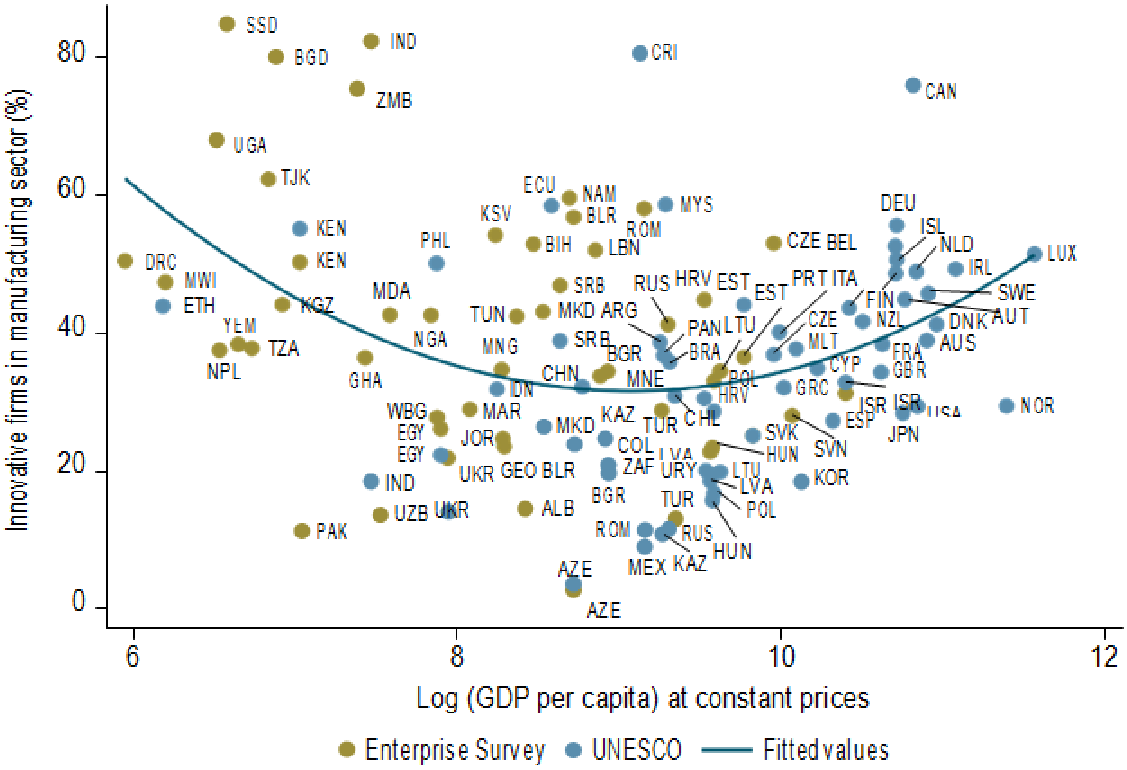
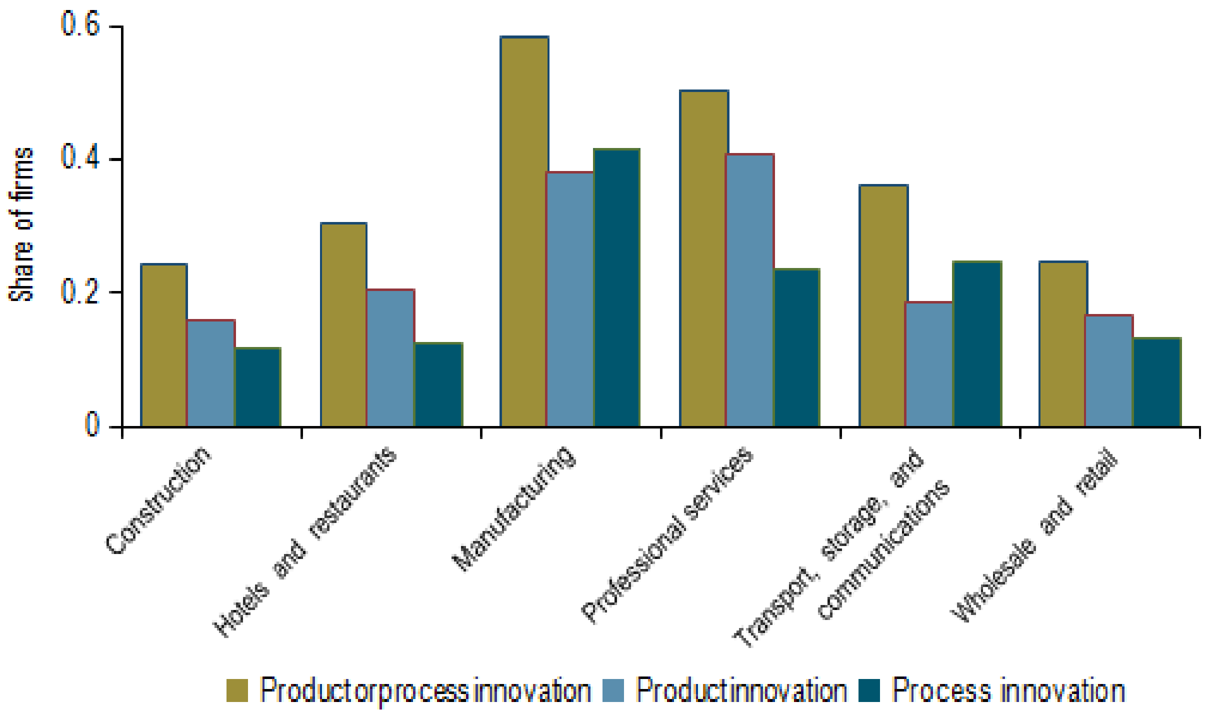
Figure 1.2 Innovation Levels Vary By Country Income
(Share Of Manufacturing Firms Reporting Product Or Process Innovation)



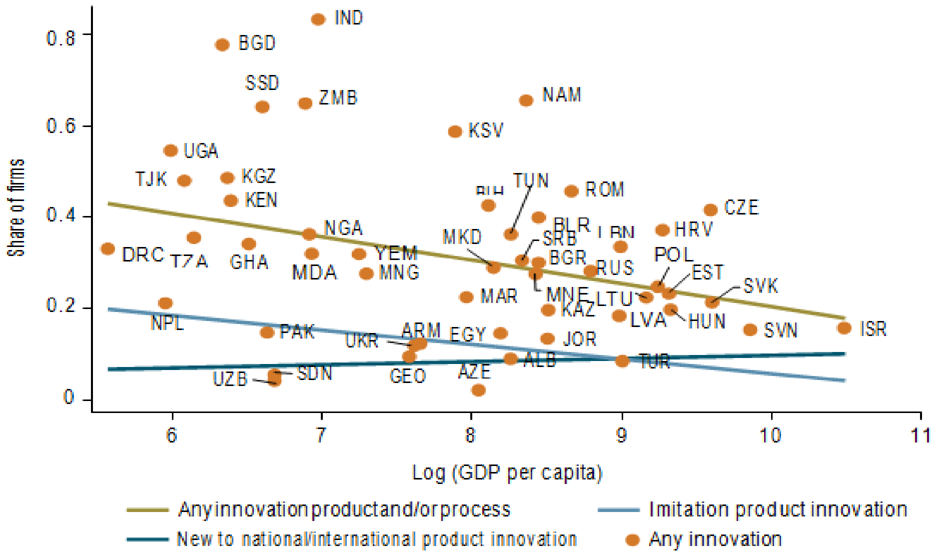
Source: Elaboration using Enterprise Survey data (www.enterprisesurveys.org) and United Nations Educational, Scientific, and Cultural Organization (UNESCO) data.
Note: GDP = gross domestic product.

Figure 1.3: All Sectors Innovate, But Innovation Rates Vary By Sector



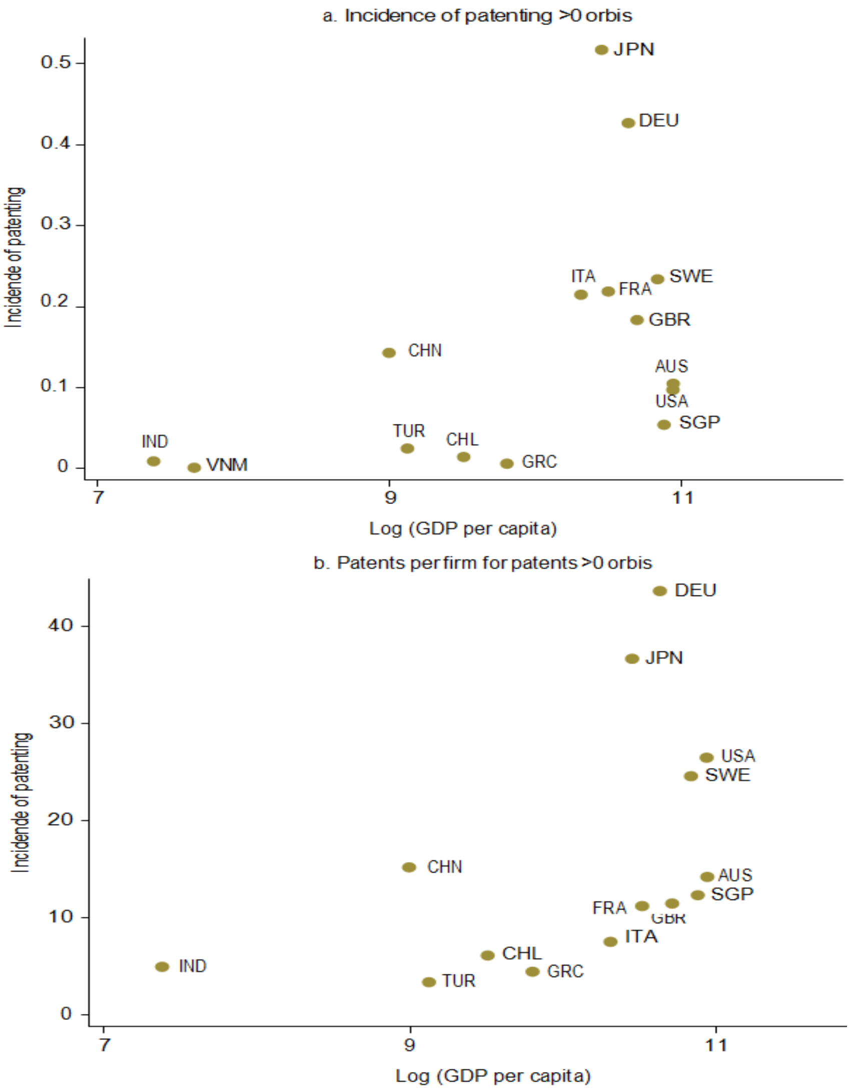
Source: Elaboration using Enterprise Survey data (www.enterprisesurveys.org).

Figure 1.4: Innovations That Are New To The Market Increase With Income Per Capita



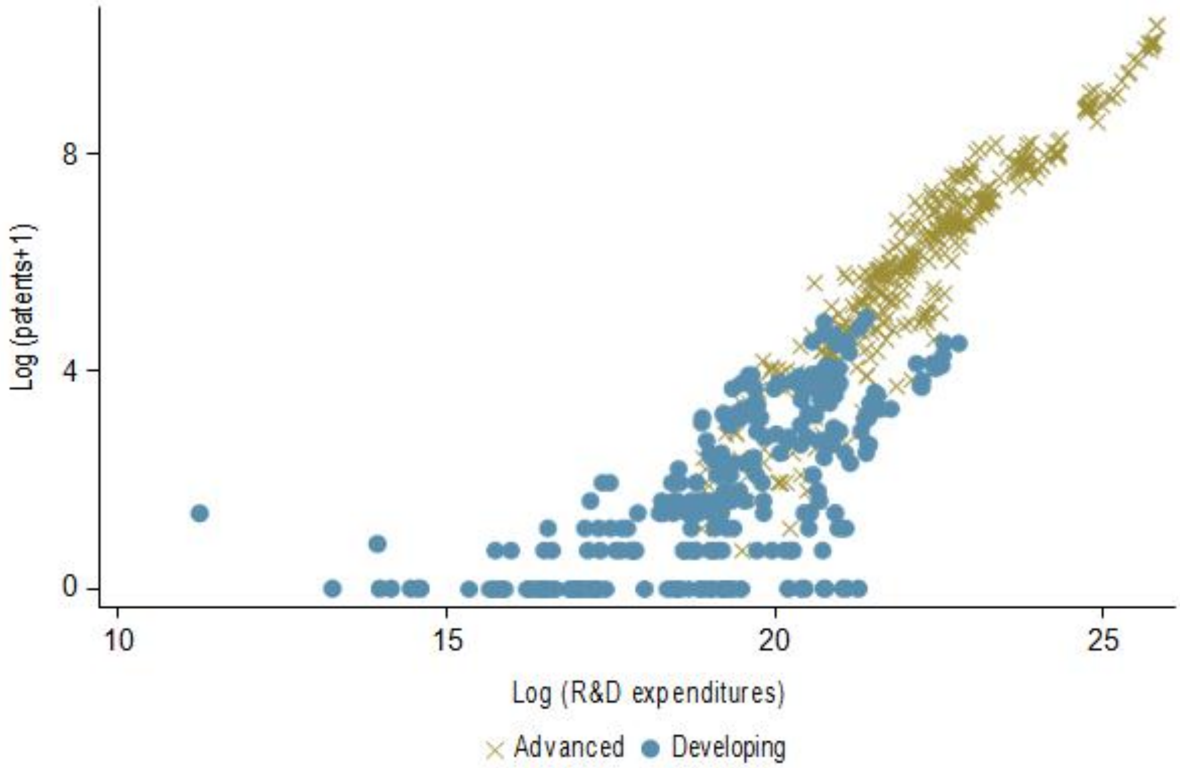
Source: Elaboration using Enterprise Survey data (www.enterprisesurveys.org).

Figure 1.5 Patenting Activity Is Much Higher In The Richest Countries



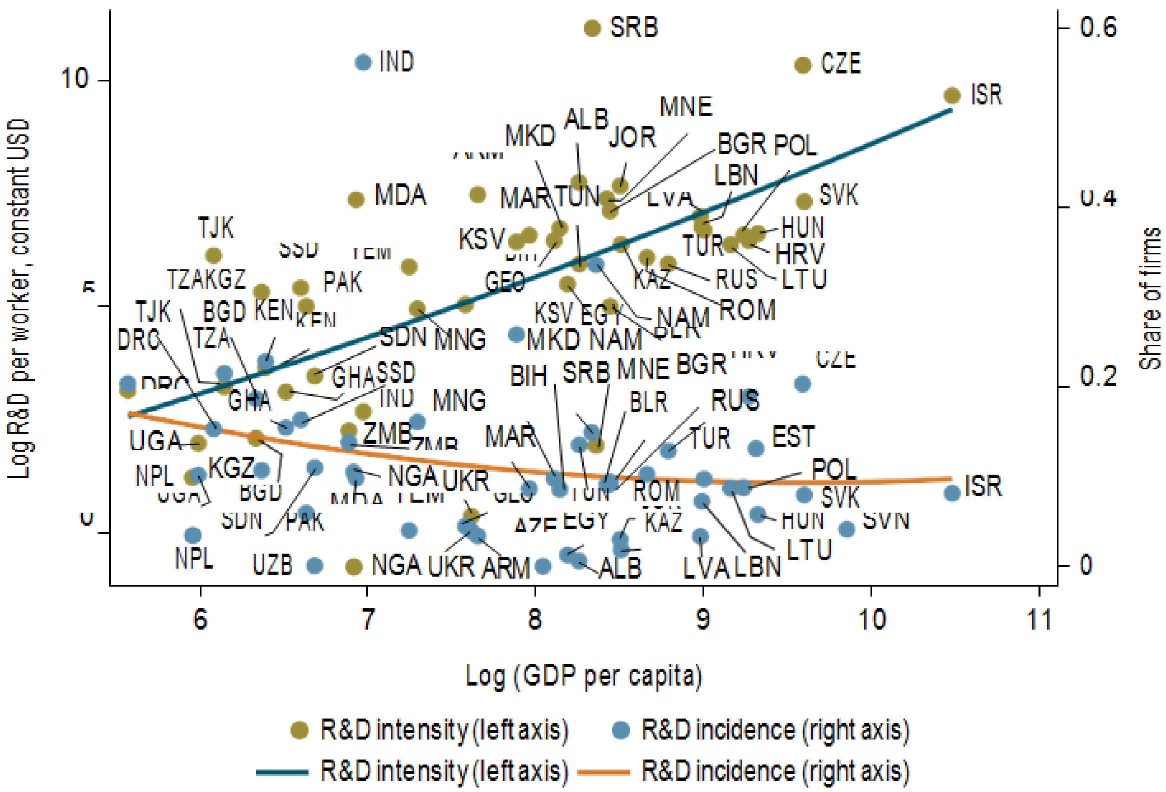
Source: Maloney and Sarrias 2017.

Figure 1.6: Patents and R&D Expenditures Are Closely Related And Rise With Income



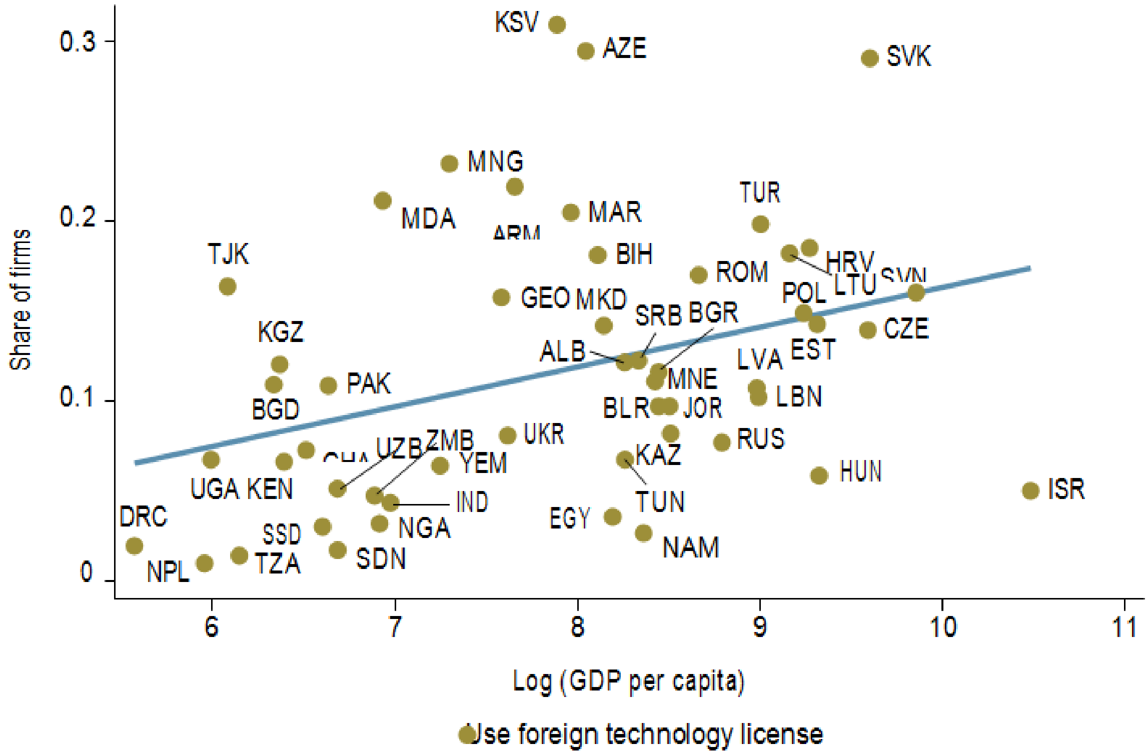
Source: Bosch, Lederman, and Maloney 2005.

Figure 1.7: R&D Intensity Rises With Income Per Capita



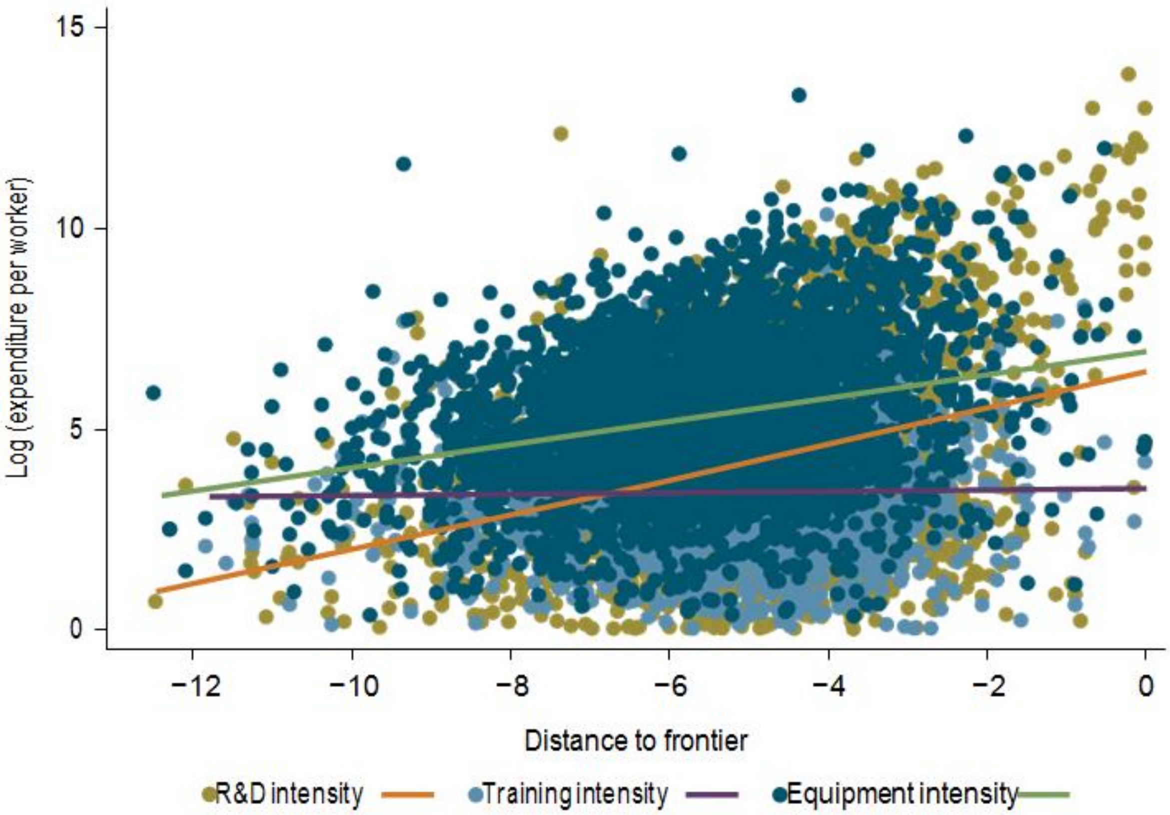
Source: Elaboration using Enterprise Survey data (www.enterprisesurveys.org).

Figure 1.8: Technology Licensing Is Lower In Less Developed Countries



Source: Elaboration using Enterprise Survey data (www.enterprisesurveys.org).

Figure 1.9: Managerial Practices Are Better In Richer Countries



Source: World Management Survey 2012.
