

Technology "make" and "buy" strategies and firm growth: firm-level evidence from Brazil

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Abstract

Introduction

Technological progress is at the heart of development. At the national level, technological progress can occur through invention and innovation, as well as through the adoption and adaptation of pre-existing but new-to-the-market technologies.

Given the still wide technology gap developing countries are facing, the bulk of technological progress in these countries occurs through the absorption and adaptation of pre-existing and new-to-the-market or new-to-the-firm technologies, typically foreign, rather than the invention of entirely new technologies.

A developing country's ability to absorb and adopt foreign technologies depends on two main factors: (i) the extent to which it is exposed to foreign technologies (the pace at which technologies diffuse across countries); this occurs mostly through trade, FDI and international migration of human capital and (ii) its ability to absorb and adapt those technologies to which it is exposed (the pace at which technology diffuses within the country).

Although the pace at which technology spreads *between* countries is accelerating, what matters most for technological achievement is the speed with which technology spreads within a country. Exposure to new ideas and techniques is not sufficient to ensure that the technology diffuses throughout the economy. While the pace of diffusion *within* countries seems to be increasing too, there is also widespread divergence across countries in the speed of diffusion (World Bank, Global Economic Prospects 2008).

A first factor explaining cross-country differences in diffusion is the level of development. Technological diffusion is slow at very low levels of development, in part because of difficulties in affording new technologies, in part because low levels of human capital severely constrain technological progress. As the level of development rises, technological diffusion increases, particularly in percentage terms, because of the low base level. At some level of development, however, the pace of technological diffusion becomes less obvious, with a high cross-country variance in technology adoption, even across countries at similar

development level. One explanation for this heterogeneity in diffusion rates at higher income levels is the divergence in the countries' ability to absorb new technologies. The speed with which a country absorbs and adopts technology depends on many factors, including the extent to which a country has a technologically literate workforce and a highly skilled elite; promotes an investment climate that encourages investment and permits the creation and expansion of firms using higher-technology processes; permits access to capital; and has adequate public sector institutions to promote the diffusion of critical technologies where private demand or market forces are inadequate.

Another explanation for the divergence in countries' performance, is a divergence in own indigenous innovative capacity, which becomes increasingly important as a country progresses closer to the technology frontier. First, own R&D complements the adoption of existing technology because it is a component of absorptive capacity. Foreign technologies frequently need to be modified so that they are suitable for domestic circumstances. For example, equipment and processes may need to be adapted to differences in the quality of inputs and in the relative abundance of labor and capital, and a stock of researchers is often necessary to understand and evaluate advanced technology, particularly as the catching up process progresses and increasingly more advanced technologies need to be adopted. Countries tend to acquire technology more readily when domestic firms have R&D programs and when public research laboratories and universities have relatively close ties to industry (Maskus 2000). But, at higher levels of development, own R&D increasingly may also start to substitute adoption of existing technologies, allowing to generate new technologies, particularly in these areas where the country has developed some comparative strengths.

Our contribution

This paper, using data from the World Bank's Investment Climate Survey (ICS) data collected in Brazil in 2003, tries to contribute to the literature on technological progress and development in several ways.

- Our focus on Brazil, allows analysing the case of a mid-income country in fast development, where the interplay between diffusion (buy) and creation (make) of new technologies, is centrepiece for sustaining growth.
- Also on the role of foreign technologies, trade and FDI, Brazil is an interesting case. Although it has recently opened up to the global economy, it still carries the reminders of a closed economy set-up, relying on its own large internal market, protecting "local champions" in strategic sectors, and with a strongly supported public sector R&D in specific technology and geographic areas.
- Because firms are the basic mechanism by which technology spreads within an economy, a micro-econometric perspective will allow investigating what drives or impedes firms to acquire and introduce technologies and how important they are for firm growth.

Using firm level data across industrial sectors and across states, we will analyse the firm, industry and regional characteristics that are able to explain the firms 'make' or 'buy' innovation strategy and their impact on firm growth.

- We can identify firm innovation strategies, on both the "make" and the "buy" dimension and explain these choices factoring in a multitude of firm characteristics, while correcting for sectoral and geographic differences. The technology "buy" strategy can be identified both as disembodied technology acquisition (licensing) and embodied technology acquisition (through the purchase of equipment, hiring of personnel...). Also information on the "cooperation" option is included. Having analyzed the choices of innovative strategies of firms in a first step, through probit and multinomial logits, the analysis will in a second step, analyse the impact of these choices on firm performance, i.e. growth.

- The dataset allows constructing a rich set of determining factors. Beyond the typical firm size and age variables, the dataset also allows identifying (i) the leading or lagging position of the firm in the technology and market competition; (ii) as a crucial component of absorptive capacity: the human capital of the firm (both its work force as its management), which can be characterized by secondary and tertiary education levels; specialized technical versus general skills; (iii) the barriers firms face in doing business, most importantly financial constraints.
- The exposure to international technology can be investigated through multiple channels: ownership, exports, import of technology (both disembodied (licensing) and most importantly, embodied in equipment), competition from imports and FDI
- The main disadvantage of the dataset is the restriction to a cross-section dimension only. The lack of a panel data structure of the dataset particularly restricts the growth part of the analysis.

The analysis

The econometric analysis will be done using the World Bank's Investment Climate Survey (ICS) data collected in Brazil in 2003. The data set contains information on 1642 manufacturing firms, which represent a random sample, stratified on the basis of size, sector and location. The firms are selected from nine sectors: food industries, textiles, clothing, leather products, chemical products, machinery, electronics, auto-parts and furniture. The entire size spectrum of firms is represented. A total of 13 states are covered by the sample.

The survey collected data on a wide variety of business aspects, including the history of the firm, the background of the entrepreneur and manager, the acquisition and status of equipment and new technology, the firm's human resources, innovation activities, as well as historical data on firm growth. Product and process innovation refer to the period 2000-2002. Firm growth, measured by sales, can be calculated for the period 1997-2002.

A preliminary analysis of the data suggest that most firms report to acquire new technology either through in-house development efforts (make), through acquiring technology (buy) or a combination of both (make & buy). Technology buy is mostly through investing in machinery. Only a minority of firms report alternative channels to acquire new technology, such as eg. hiring key personnel, licensing, from clients, university etc...

	None (275)	Make (373)	Buy (458)	Make&buy (578)
% process innovators	37.8	61.1	74.5	76.3
% product innovators	47.6	67.8	69.2	70.6
Sales growth 1997-2002	9.7	12.4	13.2	11.0

Not surprisingly, the "buy" strategies, either exclusively or in combination with "make" are the most commonly observed innovation strategies. The "make", "buy" and "make&buy" strategies are related to higher incidence of successful process innovation. Compared to a simple "make" strategy, the technology acquisition strategy seems to be more associated with the introduction of process innovations, even more so, if combined with "make" further adapting and improving the acquired technology. For product innovations, as well as for sales growth, innovation strategies matter, but the summary statistics reveal no clear preference for "make" and/or "buy". Clearly firm, sectoral and geographic characteristics will need to be factored in to explain the choices of strategies and their effects on growth. First probit analysis results, controlling for industry and location dummies and firm size and age, indicate the importance of absorptive capacity, measured by the educational level of the labour force, and the technology leading or lagging position of the firm. The international dimension in firm ownership, competition and technology sourcing appear to be less significant in explaining the technology strategy and their impact for Brazilian firms.