Complementarity of innovation policies in Brazilian industry: An econometric study ☆

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ABSTRACT

The paper aims to assess discrete complementarities in innovation policies in the context of Brazilian industry in 2003. We focus on complementarity and substitutability tests for obstacles to innovation (in the present application, lack of: finance sources, skilled personnel, cooperation opportunities, and information on technology or markets). The application, based on the Brazilian innovation survey (PINTEC-IBGE, 2003. Pesquisa Industrial de Inovação Tecnológica 2003. Retrieved October 23, 2013, from http://www.ibge.gov.br/home/estatistica/economia/industria/pintec/2003/pintec2003.pdf), avoids micro-aggregation of the data and explicitly considers sampling weights in the econometric estimation. The analysis highlights the two phases of the innovation process in terms of the propensity and intensity of innovation. We find evidence that firms subject to international competition have higher propensity to innovate. We also present some evidence that foreign ownership may be a driver to the propensity of innovation when companies actually innovate in the host countries. The evidence, unlike previous results, is not totally clear-cut in terms of contrasts of the two phases. Nevertheless, we can detect some substitutability and complementarity for specific pairs of obstacles regarding the propensity to innovate, and some evidence of complementarities in obstacles when considering intensity of innovation. Evidence is suggestive and favors the adoption of more targeted incentive policies for innovation.

1. Introduction

The role of active innovation efforts in fostering economic growth is largely recognized in the endogenous growth literature (see e.g. Romer, 1990). For developing countries, bridging the technological gap is paramount to long term growth. The nature of relationships between different types of innovation is relevant to defining appropriate incentives for innovative activities. The literature on industrial organization has emphasized inter-firm rivalry in terms of strategic complementarity or substitution as defined by Bulow et al. (1985). The former category refers to strategic decisions that mutually reinforce one another, whereas the latter considers choices that counteract one another. In an intra-firm context, it is also possible to conceive complementarity and substitution among groups of activities, as suggested by

Milgrom and Roberts (1990). In the context of innovative activities, the existence of complementarities favors the adoption of packages of incentive policies instead of isolated policies for specific factors. For example, if access to information and labor skills are identified as complementary activities, innovation policies should favor joint initiatives.

There are two approaches for empirically testing complementary innovation factors: direct (Mohnen and Röller, 2005) and indirect (Arora and Gambardella, 1990; Arora, 1996; Ichniowski et al., 1997 and Miravete and Pernias, 2006), and neither is preferred, with differences related to issues of econometric estimation due to the availability of data. The evidence weakly indicates that the prevalence of complementarities depends on the phase of the innovation process.

However, there is much we still don't understand regarding innovation policies, because of the many interaction between innovation factors, phases, strategies, and types of countries. Doran (2012) recently considers complementarity strategies associated with indicators reflecting the output dimension of innovation in terms of activities that are new to firm and market product, process innovation and organizational innovation. The emphasis on the actual outcomes of the innovative activities contrast with

the bulk of the literature that highlights the input dimension of the innovative activities often considered in terms of R&D efforts.

It is worth mentioning that the increasing empirical interest on innovation strategies reflects, in part, the more recent availability of detailed innovation surveys for different countries. Those surveys are often based on the European innovation surveys (Community Innovation Survey-CIS) (see Hong et al., 2012 for a discussion).

We try to contribute to the literature by considering a very favorable data scenario in which we are able to improve on the identification of complementary strategies for innovation policies. The motivation for the paper builds on at least three factors:

(a) The scarcity of related works in the context of developing economies. In the case of Brazil, a handful of studies (e.g. Resende and Hasenclever, 1998; De Negri, 2005 and Kannebley et al., 2005) point out the reduced level of technological effort prevalent in that country;

(b) The possibility of avoiding micro-aggregation of the data and the potential related biases that constitutes a shortcoming of the previous analogous application of the European survey data.

(c) The consideration of estimators that acknowledge the complex sampling of the innovation survey. In fact, the non-negligible heterogeneity of the Brazilian economy naturally motivates estimators that consider different probabilities of firm selection in the survey (see Pfeffermann, 1993 for an overview of the related statistical issues).

Our results indicate that firms subject to international competition have higher propensity to innovate. For a country that is shifting towards more trade barriers, the unintended consequence of less innovation is particularly important. We also find weak evidence that foreign ownership may be a driver to the propensity of innovation when companies actually innovate in the host countries.

The paper is organized as follows. The second section discusses some conceptual aspects associated with the assessment of complementarities in innovation policies and econometric strategies for assessing it. The third section discusses the data source, the empirical model and the obtained estimates. The fourth section provides some final comments.

2. Measuring complementarity in innovation factors

2.1. Conceptual aspects and main empirical results

There is a clear correlation between innovation and development. Countries have been pursuing innovation policies for a long time, but there are still marked differences between innovation patterns around the world. Innovation is a major goal of public policy, since most governments believe it is subject to more than market forces only (Aalbers et al., 2012). One does not know how to optimally allocate resources for innovation policies, even though models for innovation systems abound, both in terms of supply and demand sides. Tidd (2006) provides an introductory framework on the different aspects of national systems of innovation. Meanwhile, companies are striving to improve innovation outcomes and are searching for optimal strategies regarding assets allocation (Hess and Rothaermel, 2011).

Here we try to improve on the literature that analyses the supply side of innovation. Early models of innovation are based on a pull–push system (Tidd, 2006), and the literature has evolved beyond those simple models. However, there is still much we do not understand regarding how companies actually perform innovative activities.

One of the dichotomies related to how companies innovate is the one between complementary and substitute factors. The nature of the interrelationships among different types of innovation is relevant to defining appropriate incentives for innovative activities. In an intra-firm context, the notions of complementarity and substitution among a group of activities are suggested by Milgrom and Roberts (1990). In such cases, complementarities prevail when the increase in any subset of activities leads to an increase in the marginal return of the remaining activities. In the context of innovative activities, the existence of complementarities favors the adoption of incentive policies as a package that contemplates the relevant set of complementary activities rather than a focus on isolated incentive policies for specific innovation factors. For example, if access to information and labor skill are identified as complementary any incentive policy should consider joint initiatives on those aspects, but if a substitution relationship prevails, one should focus on a specific innovation input because each activity would tend to offset the other.

Understanding if relevant factors for innovative activities are complementary or substitutes is particularly relevant for deriving industrial policy and improving on managerial practices. Our work is closely related to the empirical literature that searches for evidence on the complementarity of innovation factors. (e.g. Athey and Stern, 1998; Mohnen and Röller, 2005 and Doran, 2012). Hess and Rothaermel (2011), for instance, analyse the pharmaceutical industry and present many interesting results based on an exploration of substitutability of factors relating to upstream and downstream parts of the value chain. One of their conclusions is the substitutive relationship between star scientists and upstream alliances, and they posit that performance effects of star scientists on firm innovation are contingent on their connections to other firm-specific resources.

Our work is not industry specific but follows an empirical strand that uses national surveys to gather insights into innovation factors pertaining to different industries. This strand of the innovation literature can be divided into two different empirical methodologies: direct and indirect. The indirect methodology can be further divided in the "correlation" and the so-called "reduced form" approaches.

The correlation indirect approach emphasizes the association between different choice variables with varying degrees of theoretical foundation (see e.g. Arora and Gambardella, 1990; Ichniowski et al., 1997 and Miravete and Pernias, 2006). The reduced form indirect approach focuses on exclusion restrictions and highlights similar effects of exogenous variables on complementary variables (see e.g. Holmström and Milgrom, 1994).

Galia and Legros (2004) undertake an indirect approach in the context of France over the period of 1994–1996 with innovation survey data (CIS2), and use both the correlation and the reduced form approaches. They consider indicators pertaining to obstacles to innovation, and use a smaller set of equations for 3 types of R&D. Besides usual controls pertaining firm size, they incorporate the importance of information sources and protection mechanisms, barriers to innovation activities, technology intensity and skilled labor. A distinctive feature of Galia and Legros (2004) is that they consider obstacles to innovation in postponed and abandoned projects and the detailed account of patent-related factors. Moreover, the study undertakes a multivariate Probit estimation for the nine types of obstacles for the postponed and abandoned projects, and considers explanatory variables that include firm size, type of ownership, group membership, internal and external R&D variables portraying technological intensity (low, medium or high), and qualitative variables related to cooperation and training. The approach for assessing complementarities is indirect because it seeks to evaluate correlations obtained upon the disturbances covariance matrix. They find that while adopting a package of