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# Innovation, Public Support, and Productivity in Colombia. A Cross-industry Comparison

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**Summary.** — We investigate the association between perceived barriers to innovation and the allocation of public support for innovation in manufacturing and service industries in Colombia, as well as the potential heterogeneity of returns to innovation across the firm-level productivity distribution. Extending the CDM recursive system, we include an equation for the allocation of direct support and use quantile regression methods to estimate the productivity equation. We find some differences across manufacturing and service industries. Financing constraints are correlated with obtaining public support in manufacturing and in some services, but in knowledge-intensive services (KIS) barriers associated with regulations are more significant. The introduction of innovations increases mostly the productivity of firms below the median of the productivity distribution, especially in services. Increasing human capital would boost productivity of firms in all industries, providing support to the hypothesis that human capital is indeed a bottleneck for productivity growth across the board in Colombia. We conclude that addressing factors that hinder innovation by low-productivity firms in all service industries could significantly contribute to increasing productivity and reduce its dispersion.
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## 1. INTRODUCTION

In this paper we contribute new evidence on the relationship between public support, innovation, and productivity at the firm level in Colombia by investigating several unexplored issues. First we identify and compare the profile of firms that have access to public support for innovation in manufacturing and service industries separately; second, we examine whether the association between the introduction of innovations and productivity varies across the productivity distribution; third, we distinguish between technological and non-technological innovation, since the latter may be especially relevant in the service industries relative to manufacturing.

Colombia has experienced a steady growth of GDP per capita during the last decade. According to a recent report by the OECD, the commodity boom and macroeconomic reforms have been driving this performance; but productivity remains low (OECD, 2015a). Developing an environment that increases the opportunities for and returns to innovation in all sectors can make a difference and complement other policies designed to stimulate sustained productivity growth, such as improving the regulatory framework, the financial system and the quality of education (Goñi and Maloney, 2014; Nguyen & Jaramillo, 2014).

Comparative empirical research carried out for several Latin American and Caribbean countries (LAC) shows that both technological and non-technological innovation increase labor productivity in manufacturing industries (Crespi, Olivari, & Vargas, 2016; Crespi & Zuniga, 2012). In 2013, however, manufacturing accounted for about 11% of GDP in Colombia, while the share of services was close to 60% and on average contributed 2.8% points to GDP growth during the period 2005–13 (OECD, 2015b). The evolution of productivity in the service industries will therefore have a significant impact on aggregate productivity and growth. The ability to innovate in these industries can be expected to play a major role in this evolution, not only because of their weight but also because

the role that some, like consulting services, play on the productivity of many other firms, especially on small and medium ones, through improving managerial capital (Bruhn Karlan, & Schoar, 2013).

Business investment in R&D in Colombia is low: it accounts for about 30% of all R&D investment, below the average rate of 40% in Latin America, which is in turn well below the 65–75% business share in advanced countries (OECD, 2014). Yet, the degree of business sector involvement in R&D and more generally in innovation is important not only for developed countries but also for countries that are or intend to be on a catching up path. Extant evidence shows that countries and firms can benefit from others' knowledge and innovations provided that they develop absorptive (technology transfer) capabilities. Investing in innovation activities, especially in R&D, enables this process (Griffith, Redding, & Van Reenen, 2004; Li, 2011).

Colombia has implemented specific policies to promote innovation in the business sector: in particular, tax deductions for R&D and technological development projects, and direct support through subsidies and loans, are available to firms. Little is known, however, about who benefits from this support, how its allocation correlates with actual or perceived

barriers to innovation and to innovation effort, and whether the returns to innovation differ significantly across the firms' productivity distribution.

To investigate these issues we use two firm-level datasets gathered by the Colombian National Statistics Department (DANE): the Survey of Innovation and Technological Development in Services, EDITS-III (2010–11) and the Survey of Innovation and Technological Development in Manufacturing, EDIT (2009–10).[1] Because these are basically cross sectional data, we mainly aim at uncovering regularities and correlations that may be informative from a policy perspective, but cannot claim to establish causal relations.

The following results stand out. Regarding access to public support, we find some differences across sectors: in manufacturing and traditional service industries the probability to obtain direct public support is higher for firms that face high financing constraints. In knowledge-intensive services (KIS), in contrast, this type of constraint is not found to be significantly associated with public support; instead, firms reporting that complying with regulations is an important barrier for innovating are more likely to obtain it. If regulations respond to efficiency criteria, this would suggest that public funds complement other polices. But if regulations create inefficiencies instead of addressing them, then public support may just be a means of partially offsetting their negative effects. We also find that in all industries firms that invest in R&D are more likely to obtain support, implying that knowledge generation, rather than pure imitation, is encouraged.

Regarding returns to innovation, we find that in manufacturing industries introducing innovations (product, process or non-technological) increases productivity at all levels of the productivity distribution. In contrast, in service industries including KIS, the introduction of all types of innovations increases productivity of firms below the median of the productivity distribution more than the productivity of those above. This suggests that less productive firms would benefit relatively more from introducing innovations, and that reducing barriers to innovation in the least productive firms would narrow down the productivity dispersion as well as increase the mean significantly.

The outline of the paper is the following: in Section 2 we address some conceptual issues, discuss closely related previous work and explain how we extend it; Section 3 contains a description of the data we use from the Colombian firm-level innovation surveys; in Section 4 we lay out the empirical framework and the hypotheses that will be tested; Section 5 discusses results, and in Section 6 we summarize our findings and draw some implications for policy and further research.

## 2. PREVIOUS WORK, CONCEPTUAL ISSUES, AND OPEN QUESTIONS

Access to data from innovation surveys conducted by national statistical offices in an increasing number of countries has enabled the expansion of empirical research on the determinants of investment in innovation and on the private and social returns to these investments. The development by Crepon, Duguet and Mairesse (1998) of an empirical framework to investigate simultaneously, at the firm level, the chain of links between the decisions to invest in innovation, the production of technological innovations, and their effect on productivity has contributed to a great extent to this progress. This empirical framework—known as the CDM model—consists basically of a system of four recursive equations where the first two model the decision to invest in R&D and investment effort, conditional on deciding to invest at all; the third models innovation output as a function of R&D investment, and finally innovation output enters the productivity equation.[2]

Cross-country comparative studies based on firm-level data for manufacturing industries in developed countries have uncovered some regularities that hold across their diverse institutional and economic environments. For example, in European countries, the probability of engaging in R&D is generally associated with exposure to international competition, firm size, and access to public funding; R&D investment intensity is highly correlated with introducing product and process innovations, and product innovation in turn is positively correlated with labor productivity (Griffith, Huergo, Mairesse, & Peters, 2006; Hall, Mairesse, & Mohnen, 2010).[3] Similar patterns are observed in manufacturing industries in emerging countries (Jefferson, Huamao, Xiaojing, & Xiaoyun, 2006).

To what extent do these regularities hold in the service industries, which account for a large share of GDP in developed countries as well as in many developing countries? Services include a large and very heterogeneous set of activities that differ from manufacturing in several respects. First, many produce mostly intangible outputs, which often present more measurement difficulties than tangibles. In addition, intangibility of many services means that they may be affected, to a greater extent than manufacturing industries, by issues derived from asymmetric information regarding service quality and properties. Some services consist precisely on the provision of information—consulting services, health, education, research, financial services—, and information goods have some distinctive traits. One of them is that their quality and value to the user or consumer may be uncertain until it is consumed; this may provide more room for problems such as adverse selection and moral hazard, which are consequences of the asymmetric information situation between the two parts of a transaction. It is well known that asymmetric information can generate market failures in financial, insurance, and health services. These market failures are likely to affect costs and rewards of innovating. For instance, they can raise the cost of capital for corporations, reducing investment in general (Choi, Li, & Yan, 2013).

A second difference between manufacturing and service industries is that competitive pressure varies across activities: only some services are internationally traded, in contrast to manufacturing goods. Even when technically feasible, trade in services may be further restricted through regulations. In this regard, the OECD computes a Services Trade Restrictiveness Index (STRI) for 42 countries and reports that in the case of Colombia this index is below the average in 18 out of 22 sectors, with legal, architecture, engineering, and road transport among the lowest. However, telecommunications, insurance, and broadcasting are at or above the mean, which means that trade-related regulations in these activities could be further improved.[4] Openness to trade is usually positively correlated with innovation, both in manufacturing and services (Zahler, Iacovone, & Mattoo, 2014). More broadly, trade and institutional quality are found to be correlated with productivity growth, one of the channels being their impact on international knowledge diffusion (Coe, Helpman, & Hoffmaister 2009).

Third, and related to the previous point, additional government regulations such as restrictions to FDI, barriers to entry, and conduct regulations affect many services (telecommunications, professional and financial services, utilities, health services, education). These regulations may influence firms' incentives to innovate or to adopt innovations, and ultimately