Innovation and Productivity in the Colombian Service Industry

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Abstract*

This paper presents the results of a study on the ways that innovation and productivity are connected in the Colombian manufacturing and service industry. Using data from the Manufacturing Innovation Survey (2007–2008) and the Service Innovation Survey (2008–2009), the paper addresses two main questions: first, whether patterns of innovations differ among manufacturing and services industries, and second, whether service firms innovate, and, if so, whether their innovation approach differs from that of manufacturing. The main findings are (1) that service firms engage in process innovation, both technological and non-technological; (2) that the probability of undertaking innovation increases with investment in R&D labs and firm size, regardless of the industry; and (3) that the more intensive the investment in innovation, the higher the probability of introducing innovations. The econometric results show that the response is higher in manufacturing than in services. Finally, labor productivity is greatly enhanced by the introduction of innovations, although surprisingly the estimated coefficient shows that the effect is larger for service industries than for manufacturing industries.

JEL classifications: L6, L8

Keywords: innovation, productivity, service and manufacturing industries, Latin America

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Contents

1. Introduction

This paper presents the research results of a study on the ways in which innovation and productivity are connected in Colombian manufacturing and service industries. Using data from the Manufacturing Innovation Survey (2007–2008) and the Service innovation Survey (2008–2009), the paper addresses the following questions. Do patterns of innovations differ between manufacturing and service industries? Do service firms innovate, and if so, is their innovation approach different from that of manufacturing?

When innovation is seen from a broad perspective, that is, as the introduction of new or improved products, processes, or technological innovations, and the improvements in areas such as logistics, distribution, and marketing (non-technological), it can be argued that the more a country innovates, the better its economic standard of living or economic development becomes (Fagerber and Srholec, 2007). Therefore, understanding the mechanisms leading to the decision to begin an innovative activity, which ends with the introduction of the innovation and the subsequent productivity improvement, is important, not only at the micro level of analysis but also for policy decisions.

Based on the seminal idea of Griliches and Mairesse (1984), a novel framework of analysis called CDM (named for Crepón, Duguet, and Mairesse, 1998) has been used to assess the impact of innovation on productivity. The methodology involves three steps. The first step links the decision to innovate with the intensity of investment in innovation. The second step presents the knowledge production function, or how the intensity of innovation impacts the introduction of innovations. The final step shows how innovations directly affect firm productivity. This framework has been used extensively to study innovation productivity in manufacturing, but there is scant literature on that same relationship for the service industries. Service industries do not produce tangible goods and do not appear to add value to production, and their productivity also seems low compared to manufacturing. However, the value added of the service sectors as a percentage of GDP fluctuates around 80 percent in most developed economies. It is thus important to study how innovation can affect productivity.

This study contributes to the empirical literature on innovation in three ways. First, it analyzes the effect of innovation on productivity for Colombian manufacturing, using a more recent wave of the Manufacturing Innovation Survey. Second, for the first time, a complete analysis of patterns of innovation in services and the effects of innovation on productivity is undertaken. Last, the way service and manufacturing firms innovate is compared, as are the ways some key variables affect and are affected by innovation, that is, through productivity.

The main findings are that service firms engage in innovation processes, both technological and non-technological. Second, the probability of undertaking innovation decisions increases with investment in R&D labs and with the size of the firms, regardless of the industry. Third, the more intensive the investment in innovation, the higher the probability that firms will introduce innovations. The econometric results show that the response is higher in manufacturing than in services. Finally, labor productivity is greatly enhanced by the introduction of innovations, although, surprisingly, the estimated coefficient shows that the effect is bigger for the service industry than for the manufacturing industry.

The remainder of the paper is structured as follows. Section 2 reviews the literature on innovation, particularly that focused on the service industry. Section 3 analyzes Colombian service industries and their recent performance. The data are described and the main patterns of innovations across manufacturing and services are analyzed. Section 5 presents the CDM model specifications, the econometric procedures, and the variables used. Section 7 presents the econometric results, and Section 8 concludes.

2. Literature Review

The role of innovation in economic and social change was one of the main contributions of Schumpeter (1983), who pioneered the analysis of innovative activities (Fagerberg, 2005).[1] Although he did not formalize his ideas, subsequent strands of economic theories, such as neo-classical growth theories and neo-Schumpeterian theories, attempted to measure the impact of innovation on economies at the macro and at the firm level (Cohen, 2010). The main rationale behind the connection between innovation and economic growth is either through creative destruction, that is, entrepreneurship, "where innovation is the essence of new, independent companies creating new industries or acting as major agents of change in established industries" (Damanpour and Aravind, 2011: 5) and by which new and more efficient technologies, generally speaking innovations, replace old, less efficient ones; or creative accumulation, which implies that firms, through their accumulated profits, have incentive and means to carry out innovations (Malerba and Orsenigo, 1995; Damanpour and Aravind, 2011). Both kinds of dynamic processes lead to greater profits for innovative firms, which in turn can get firms to follow a virtual (or not) path of more innovation, more profit.

Research on the importance and effect of innovation in service industries was scant until recently. According to Cohen,

> "A major lacuna in our understanding of the determinants of innovative activity and performance is our virtual ignorance of innovation in the service sector, with the exception of a modest literature on financial services. This gap is not simply a matter of a lack of data. It speaks to our very notion of innovation, and how to capture innovation when a good deal of it occurs outside of R&D labs, and especially in the context of client-specific relationships. This is, however, also associated with the way R&D is measured—and not. For example, if a firm innovates in the course of providing service to a client, accounting conventions require that that be counted as cost of goods sold; it cannot be considered R&D for reporting purposes. And a good deal of innovation in the service sector occurs in just this fashion" (Cohen, 2010: 98).

[1] In his own words, "I was trying to construct a theoretic model of the process of economic change in time, or perhaps more clearly, to answer the question how the economic system generates the force which incessantly transforms it." (Quoted in Hall and Rosenberg, 2010: 4)

The lack of research on service innovation in emerging economies was one of the main reasons for undertaking the present study on innovation in the Colombian service industry. It is clear that innovation is the key to technical and social change and to greater economic growth, but why would innovation in service be important to study? First, the service sectors have become the largest fraction of GDP and the main source of employment in both developed and developing economies. Therefore, it is important to understand the factors that affect their development, including innovation. In most developed economies, the dynamism of manufacturing is explained by the innovation in service-related activities, that is, the provision of bundled post-services. Second, service industries in key sub-sectors are composed of large firms that try to exploit economies of scale. Therefore, the changes in their internal organization have become key in improving the efficiency of innovation (Hertog, 2010). These two arguments imply that innovation in services goes beyond the service sectors where the innovation takes place to affect service activities across *all sectors* of an economy. More often than not, services are key agents in transferring, supporting, and originating innovation in other sectors (Miles, 2005).

Research on innovation in services has been categorized in four general approaches (Tether, 2005; Tether and Howells, 2007; Gallouj and Savona, 2009; Gallouj and Windrum, 2009; Vence and Trigo, 2009; and Hertog, 2010). From a neo-Schumpeterian standpoint, Gallouj and Savona present a thorough and critical review of all of them. The first two approaches share some similarities. One of them, called the neglect view, states that service sectors do not add value to economic development. The authors view innovation narrowly and are concerned more with the object-base approach to identifying and measuring innovations. They conceive of innovations as "hard" or tangible objects. The second approach, known as the assimilation view, considers service sectors as passive subjects in the innovation process. Under this approach, service activities only innovate through the embodied technologies that they have acquired. This view falls into the "supplier dominated" characterization described by Pavitt (1984).

The third and fourth approaches are more subject-based. The third, known as the "demarcation approach," states that "service-specific forms of innovation exist…(and) highlight the importance of organizational innovation, which appears to go hand-in-hand with product and process innovations in services (…)" (Gallouj and Windrum, 2009: 143). This approach stresses two features of innovation in the service sectors. One is the “co-production thesis,” which argues that service industries are characterized by a high degree of interaction between the user (demand) of a service and the service provider. This feature is clearly evident in knowledge-intensive business service (KIBS) activities. According to Gallouj and Windrum “Together with their clients, KIBS detect new needs, define product specifications, and act as an interface between client firms and other actors within innovation networks (e.g., suppliers and business service providers)” (2009: 143). By doing so, the core of innovation in services, such as KIBS, is “the organizational innovation and its relationship to product and process innovation, input and market innovations” (Gallouj and Windrum, 2009: 143). Innovation is then viewed as a networked process, not an isolated one. The second aspect argued by this approach is the ad hoc nature of innovation, which says that innovations are solutions to client-specific problems and then are non-reproducible. One can visualize it as a learning process what puts skills in the forefront of the service innovation process.

A fourth approach is the synthesis, developed more recently. It argues that the innovation process in manufacturing and services shares the neo-Schumpeterian framework of both technological and non-technological forms of change. The emphasis of this approach is to devise some “best” frameworks that account for the main features of innovation in manufacturing and services. In this view, the study of innovation not only in services but also in manufacturing should involve tools and theories from organizational behavior, social networks, marketing, strategy and communications studies that allow the construction of different and better-suited indicators of the innovation process.

The two views described above share some features. They stress the heterogeneity of service activities and the need to devise new ways of measuring innovation. They recognize that soft technologies can be more important in the innovation process for service firms than hard ones. This is a salient point, since it highlights non-technological factors, such as human capital or skills, organizational structures and marketing activities, as key in the innovation process. Third, they emphasize that there is a considerable variety of types of innovation within the service sectors.

Recently, some authors have analyzed the way that innovation in service sectors is linked to or molded by ICT adoption at the firm level (Gago and Rubalcaba, 2007; van Leeuwen, 2008). Gago and Rubalcaba highlight some of the features of the demarcation and synthesis approaches of innovation in the service sector. The way that non-technological aspects of innovations, such as organizational innovations and co-production schemes, interact with the other common innovations outputs are highlighted. Their contribution is to put information and communication technologies (ICT) as drivers of those services and processes, as facilitators of the networked two-way process of innovation between users and providers of innovation, and as agents of the use of new innovations based-ICT.

3. Objectives

The objective of this paper is to understand the determinants of innovation decisions and the impact of innovation of productivity in the service and manufacturing sectors in Colombia. Several specific hypotheses are tested. First, from the descriptive statistics of the data, we hypothesize that Colombian firms that undertake R&D engage more in innovative activities. Second, for those manufacturing and service firms that engage in innovative activities, the more they invest in innovation, the more they innovate either in technological or non-technological innovations. Third, labor productivity will increase as firms innovate more, and the more money they invest in innovation, the higher the productivity will be.

4. National Background Production Structure and Policies

4.1. Innovation Policies

Since the early 1990s, successive Colombian governments have been planning and implementing a wide array of projects designed to increase national capabilities in science and technology. Law 29 of 1990 created the National System of Science and Technology (S&T) for the purpose of increasing productivity and competitiveness in the country. S&T was thought to be a key cross-sector policy of the new and more open economic development policy. Since then, several changes have taken place in policies designed to strengthen Colombian capabilities in science and technology. The country's National Development Plan (2006–2010) stressed the enhancement of innovation capabilities as competitive factors that boost the competitiveness of Colombian firms in national and international markets.

Two main policies were undertaken for that purpose. The first was the enactment of Law 1286 of 2009, the Law on Science, Technology, and Innovation, which is aimed at strengthening the National System of Science and Technology and COLCIENCIAS.[2] The law makes explicit the introduction of "innovation" as a tool of science and technology that can also lead the country to greater economic development. This new emphasis is reflected in the increased resources devoted by COLCIENCIAS to innovation activities in the productive sector. The second change is the status of COLCIENCIAS, which became an administrative department agency,[3] which raised its profile and gave it greater autonomy. This law keeps the main objective of COLCIENCIAS as to incorporate science, technology, and innovation as a crosscutting pillar of the economic and social policies of the country. Despite these policies, COLCIENCIAS' budget was still dependent upon National Planning Department and the Ministry of Finance and therefore lacked real financial and discretionary independence.

The innovation policy in Colombia underwent a decisive change in 2011 after the passage of Law 005, which created the General Royalties System (*Sistema General de Regalías*, or SGR). Pursuant to this law, royalties paid by firms that exploit non-renewables resources can be used for economic development. Law 005 of 2011 also created the Science, Technology and Innovation Fund, which receives funds equivalent to 10 percent of the SGR. In 2012, the CTEL received some US$470 million, which increased COLCENCIAS' financial independence.

It is important to explore how public policy on S&T has affected the service sectors. Since the early 1990s, Colombian governments have focused on implementing sectoral policies without favoring any specific industry or sector. COLCIENCIAS, as the leading institution in implementing the National Innovation Strategy, and the National Department of Planning, as the institution responsible for planning innovation policies, are the two main institutions related to innovation. Two main strategies related to the present study have recently been carried out by these two bodies, having to do with training of human capital and innovation at the firm level and entrepreneurship. These strategies are implemented through and with the involvement of certain ministries and other government agencies. In 2012, 12 projects related to the electronics, telecommunications, and informatics industries received about US$1.6 million, and seven

[2] COLCIENCIAS is the Colombian equivalent to the United States' National Science Foundation.
[3] A highest rank government office, comparable to a ministry or department.

projects related to industrial technological development and quality received about US$1.3 million.

Complementary but isolated efforts designed to increase the innovative capacities of firms, regardless of industry, were put in motion by two ministries. In 2000, Law 590 created FOMIPYME as a special account managed by the Ministry of Commerce, Industry, and Tourism with the aim of financing projects, programs, and activities to promote technological development in micro and small and medium enterprises (SME). Recently, Law 1450 of 2011 created the Fund for the Modernization and Innovation of Micro, and SME Firms" called "INNpulsa Mipymes," managed by BANCOLDEX. This ministry has also supported the management of the Regional Competitiveness Commissions (CRC), specifically to link tasks with the Regional Councils of Science, Technology, and Innovations (Consejos Regionales de Ciencia, Tecnología e Innovación, or CODECTIS) supported by COLCIENCIAS). It has implemented the Productive Transformation Programs[4] in conjunction with Proexport and has led the conversion of BANCOLDEX to the Bank of Entrepreneurial Development.

For the past several years, the Ministry of Information and Communication Technology has promoted ICT social programs such as COMPARTEL, which supports access by micro and SME firms to ICT, especially in rural areas. This ministry also created a program called Mipyme Digital, aimed at providing funds for partial reimbursement to firms that adopted new ICT in their productive processes. Adoption of new hardware and software and access to the Internet are among the factors that the program favors. These efforts are aimed at all economic activities with the intention of allowing firms to overcome financial obstacles and to incentivize innovation, organizational change, and training.

4.2. Production Structure

The service sector in Colombia is the most dynamic and important sector of the economy. The statistics collected by the National Bureau of Statistics in Colombia (*Departamento Administrativo de Estadisticas*—DANE) show the importance of services using indicators such as employment, distribution of value added, and growth. The Colombian service sector and trade

[4] The Productive Transformation Program is a public-private partnership created by the Ministry of Commerce, Industry, and Tourism that seeks to develop the productivity and competitiveness of sectors with high export potential. Today, there are four programs for the service industries: (a) outsourcing of BPO&O business (*Terciarizacion de procesos de negocio* BPO&O, (b) electrical energy, goods, and related services, (c) software and IT, (d) nature tourism, and (e) health and wellness tourism.

activities made up 81 percent of firms and 82 percent of total employment in 2005 (Census 2005, DANE). The national accounts also show the large participation of service sector in the Colombian economy compared to the manufacturing sector.

Table 1 reports the distribution of value added and the annual growth rate over the last 10 years. The share of all service activities, including financial and insurance services, has been fairly constant, averaging about 54 percent compared to 13 percent in manufacturing and 7 percent in the agricultural sectors. Table 1 also presents the recent dynamics of all economic activities in Colombia. Service activities have, on average, grown above the average of the whole economy, both in terms of value added and GDP.

Table 1. Added Value by Branches of Economic Activities *(National Accounts Classification)*

Sector	2001		2002		2003		2004		2005		2006		2007		2008		2009		2010[p]	
	Share	Growth	Share	Growth	Share	Growth	Share	Growth	Share	Growth	Share	Growth	Share	Growth	Share	Growth	Share	Growth	Share	Growth
Agricultural cattle activities, hunting and fishing	**0.07**	**1.76**	**0.08**	**4.54**	**0.08**	**3.09**	**0.07**	**2.97**	**0.07**	**2.81**	**0.07**	**2.37**	**0.072**	**3.91**	**0.06**	**-0.37**	**0.06**	**-0.65**	**0.06**	**0.95**
Mining and quarrying	0.071	-8.26	0.06	-1.77	0.06	1.69	0.06	-0.90	0.06	4.05	0.06	2.42	0.05	1.49	0.06	9.65	0.06	11.08	0.07	12.27
Manufacturing industries	**0.13**	**2.91**	**0.13**	**2.13**	**0.13**	**4.89**	**0.14**	**7.94**	**0.14**	**4.48**	**0.14**	**6.80**	**0.14**	**7.20**	**0.13**	**0.51**	**0.12**	**-4.13**	**0.12**	**2.89**
Public utilities: electricity, gas and water	0.04	3.18	0.04	0.83	0.04	4.52	0.04	3.45	0.04	4.14	0.03	4.75	0.03	4.08	0.03	0.49	0.03	1.87	0.03	1.23
SERVICE ACTIVITIES	**0.54**	**5.50**	**0.54**	**12.33**	**0.54**	**8.30**	**0.54**	**10.74**	**0.54**	**6.87**	**0.54**	**12.14**	**0.54**	**8.33**	**0.54**	**8.81**	**0.54**	**5.26**	**0.54**	**-1.73**
Commerce, repariments restaurants and hotels	0.11	2.91	0.11	1.49	0.11	3.72	0.11	7.09	0.11	5.03	0.11	7.88	0.12	8.27	0.12	3.13	0.11	-0.32	0.11	5.09
Transport, storage and communications	0.06	3.28	0.06	2.76	0.06	4.51	0.06	7.56	0.06	7.81	0.07	10.76	0.07	10.94	0.07	4.58	0.07	-1.38	0.07	4.98
Financial firms, insurance, real state and services to firms	0.19	1.21	0.19218704197258	2.98	0.19	3.92	0.19	4.60	0.19	4.97	0.19	6.44	0.19	6.81	0.19	4.52	0.19	3.10	0.19	2.89
Social, community and personal activies	0.16	1.25	0.16	1.73	0.16	1.98	0.16	4.10	0.15	3.49	0.15	4.35	0.15	5.02	0.15	2.59	0.15	4.35	0.15	4.79

A more complete picture of the service industries dates from 2004, when DANE began surveying firms in some service sectors on an annual basis. However, because it included different service sectors, it was not until 2006 that comparable data containing the same service sectors was being collected and reported annually. The services surveyed are: (i) hotels and restaurants; (ii) real estate and entrepreneurial activities; (iii) private higher education; (iv) private activities related to human health; (v) storage, communications, and auxiliary transport activities; and (vi) entertainment and other activities. The number of firms included in the survey by year and activity changes year to year from a sample of selected companies. Table 2 shows the number of firms for each sector in each year from 2006 to 2010. The most representative sector is real estate and entrepreneurial activities, which makes up almost 52 percent of the sample.

Table 2. Number of Firms Surveyed in EAS

	2006	**2007**	**2008**	**2009**	**2010**
Hotels and restaurants	524	523	521	578	567
Real estate and entrepreneurial activities	1.995	1.995	2	2.132	2.189
Private higher education	143	143	147	150	151
Private activities related to human health	646	642	649	738	739
Entertaiment and other activities	184	186	181		
Storage, communications and auxiliary transport activities	546	539	531	532	561

We now discuss some standardized indicators in the service sector in Colombia that can help pose formulate hypotheses on innovation decisions and their impact on labor productivity. The indicators for 2006 to 2010 that illustrate performance are: (a) the ratio of value added to gross production, and (b) labor productivity. Panel A in Table 3 shows the ratios of value added to gross production for the six sectors. The main insight is that the ratio varies considerably from one sector to another. In general, the private higher education sector and the real estate and rental activities sector have the highest ratios. They show on average that for every monetary Colombian peso of gross production, the sector contributes about 67 to 74 cents. Activities such as hotels and restaurants have ratios under 40 percent. The second point we observe from Panel A is the high year-over-year variability of the indicator for all six sectors. For some of them, the ratio increases, and for others it decreases. It is beyond the scope of this study to explain these features, but they can provide some clues about the different modes of innovation of Colombian service sectors.

The differences in productivity may also hide some discrepancies in the way that performance is measured in the service sectors. Is productivity, measured as value added per worker, a good approximation of performance in the service sectors? As a measure of performance, average labor productivity can be used to compare across different sectors but that measure hides different output-input relationships. Djellal and Gallouj warn about the potential misuse of productivity as a measure of performance since for many services industries it is "debatable whether the concept should be retained, either because an indicator is wrongly considered to reflect productivity, when in fact it does not, given the technical solutions adopted, or because extraordinary measures are being taken to keep a non-valid indicator alive" (2013: 296).

Panel B in Table 3 shows (average) labor productivity, or the ratio of real value added to total workforce used in the delivery of a service. The reader must bear in mind that the number of firms involved in a specific year can differ from the number in other years. A couple of stylized facts are worth mentioning. First, labor productivity is relatively similar across sub-sectors with the exception of two sectors: hotels and restaurants and real estate and entrepreneurial activities. In those two sectors, it ranges from a low of US$18,926 in human health activities in 2009 to a high of US$25,666 in hotels and restaurants in 2010. The two sectors have labor productivities that are half (or even lower than) of the productivity of the other service industries in the table. These are storage and communication services, and entertainment activities: the first one with a very high productivity above US$130,000, while the second has a productivity rate of above US$51,000. The second interesting fact is the somewhat different trend in productivity for most of the services. Storage and communications, as well as real estate and rental activities and human health sub-sectors, show declining productivity, more so in the case of storage and communications. Hotels and restaurants and entertainment, on the other hand, present a less clear declining trend.

Table 3. General Indicators in Service Sector

	Panel A: Ratios of Value Added to Gross Production				
	2006	**2007**	**2008**	**2009**	**2010**
Hotels and restaurants	0.37	0.36	0.37	0.36	0.36
Real estate and entrepreneurial activities	0.7	0.69	0.7	0.75	0.75
Private higher education	0.68	0.68	0.68	0.66	0.66
Private activities related to human health	0.30	0.28	0.27	0.26	0.26
Entertaiment and other activities	0.36	0.38	0.40		
Storage, communications and auxiliary transport activities	0.50	0.48	0.48	0.48	0.47

	Panel B: Labor Productivity				
	2006	**2007**	**2008**	**2009**	**2010**
Hotels and restaurants	25,613	24,691	24,907	23,826	25,666
Real estate and entrepreneurial activities	20,399	20,375	19,994	18,925	19,067
Private activities related to human health	38,343	39,833	38,442	33,949	31,377
Entertaiment and other activities	51,573	55,474	54,527		
Storage, communications and auxiliary transport activities	154,081	143,355	134,971	133,305	129,401

5. Data and Descriptive Statistics

In this project, we use different information and data sources designed and collected by DANE. The major sources of information are the innovation surveys of the services and manufacturing sectors for the last biannual sampling period, which corresponds to 2008–2009 at the EDIT-2 in the service sector and 2007–2008 at the EDIT-4 for the manufacturing sector. The second source of information is the annual economic surveys in the service and manufacturing sectors. For the service sector, we use the annual economic survey (EAS), and for the manufacturing sector we use the annual economic survey (EAM). The last two surveys use economic indicators such as sales, sales abroad, investment in physical capital, value added and capital ownership, and so on.

The innovation surveys are comparable in term of the structure of instruments and innovative indicators for both the service and manufacturing sectors. The surveys differ in the sampling design and the coverage of firms. The EDIT-4 has the same sample as the annual manufacturing survey EAM, which surveys all firms larger than 10 employees. Conversely, the EDIT-2 covers a *sample* of service sector firms following the same sampling design as the EAS. Therefore, neither the EAS nor the EDIT-2 represents the universe of firms in the service sector.

In order to conduct the econometric analysis of innovation and productivity in the service and manufacturing sectors, an ID of each firm included in the economic and innovation surveys must be matched. DANE performed the matching of the databases at the request of the research team. Because of the restrictions on data access, we could only receive the matched sampling of firms for manufacturing and service sectors at DANE's headquarters. The final database used for the econometric estimation yielded 7,680 firms for the manufacturing sector with complete information on economic and innovation activities and 1150 firms for the service sector. After checking for missing values for the dependent and explanatory variables used in the whole CDM model, the final working sample for manufacturing was 7,295, and 687 firms for the service sector.

5.1. Key Definitions of Variables[5]

5.1.1. Innovation Indicators (Output)

Part of the rationale for the synthesis or integrative approach to innovation in services is that innovation should be viewed more broadly and should include non-technological as well as technical changes. Following that approach, we construct two groups of innovation indicators in order to capture the different ways that the service sector innovates: (a) technological innovation, and (b) non-technological innovation. Finally, to supplement these two output indicators of innovations, we add indicators from the input side of the innovation process.

[5] A table with the definition of each variable used at the analysis will be found at the annexes.

5.1.2. Technological Innovations

The mainstream research in innovation defines technological innovation as the development or application of new technologies. Following this line of research, five technological innovation indicators are constructed: (i) *product innovation*, or the percentage of firms that reported having introduced at least one product innovation; (ii) *process innovation*, or the percentage of firms that reported having introduced at least one process innovation; (iii) *innovative firms*, or the percentage of firms that reported having introduced at least either one process or one product innovation; (iv) *New-to-firm innovation*, or the percentage of firms that reported having developed an innovation that was new for the firm; and (v) *new-to-market innovation*, or the percentage of firms that reported having introduced innovation new for either national or international markets.

5.1.3. Non-technological Innovations

Non-technological innovations are more difficult to characterize since they supposedly do not include either a development or an application of new (often hard) technologies. Schmidt and Rammer (2007) state that non-technological innovations "may solely rest on the use of new business methods, new organizational concepts or other immaterial ways of changing business activities" (Schmidt and Rammer, 2007: 4). These immaterial changes are affected by factors such as uncertainty on the returns, spillover effects, investment and financing expenditures and impacts on demand and costs, although perhaps to a lesser degree. In general, the Oslo Manual has defined two major non-technological innovations: (a) marketing innovations, and (b) organizational innovation. Following that definitions, and questions of EDIT-2, we construct three indicators: (a) *Marketing innovation*, or the percentage of firms that reported having introduced at least one marketing innovation, (b) *organizational innovation*, or the percentage of firms that reported having introduced at least one organizational innovation, and; *non-technological innovation*, or the percentage of firms that reported having introduced at least one marketing innovation or one organizational innovation.

5.1.4. Innovation Indicators (Input)

Researchers on innovation have also made use of data on innovation from the input side, that is, the decision to invest money in innovation activities and the amount invested. For the purpose of this study, we present four input indicators of innovation. The first one is a dummy variable that takes the value of one if a firm decides to invest in research and development—R&D—activities, and zero otherwise. The share of firms that decided to invest in R&D is the ratio of the sum over all firms responding yes to the total number of firms. This has been a key indicator of a national level of technological and scientific development. The second variable is the decision by firms to invest in ICT. It follows the same rule as the previous indicator. The third indicator is constructed from all of the responses to the decision to invest in innovation activities other than R&D and ICT. It is a dummy variable that takes the value of one if the firm reported to have invested at least in one of those activities, and zero otherwise. The next procedure is the same as in the first indicator. The last indicator is more comprehensive and is also a dummy variable that takes the value of one if the firm reported to have invested in at least one of the innovation activities, including R&D and ICT.

5.2. Innovation Modes in the Service Sector: Key Differences with Manufacturing

In this section, we describe the completed (unmatched) innovation outcomes of Colombian service sector firms, using EDIT-2, and compare them with the outcomes of the manufacturing firms. The main objective is to see first the main patterns of innovation in each enlarged activity and second, to see whether there exist different patterns of innovation outcomes between service and manufacture firms. Table 4 presents the innovation behavior indicators for service and manufacturing activities.

Table 4. Innovation Behavior *(Colombian Manufacturing and Service Sectors)*

	N	Technological Innovation					Non-technological Innovation				
		Product	Process	Innov. firms (1)	New-to firm (2)	New-to market (3)	Organization	Market	Non-tech innovation (4)	Any innovation (5)	Innov. in all (6)
All service industries	**3.662**	**0.332**	**0.211**	**0.406**	**0.381**	**0.131**	**0.225**	**0.143**	**0.279**	**0.472**	**0.05**
KIBS	616	0.412	0.26	0.48	0.533	0.243	0.258	0.18	0.321	0.531	0.081
Traditional	2.537	0.266	0.184	0.346	0.328	0.087	0.198	0.126	0.252	0.423	0.035
National	3.34	0.328	0.206	0.402	0.382	0.122	0.223	0.138	0.274	0.468	0.049
Foreign	322	0.375	0.26	0.456	0.394	0.223	0.242	0.192	0.332	0.515	0.065
All manuf. Industries	**7.683**	**0.225**	**0.146**	**0.268**	**0.248**	**0.095**	**0.088**	**0.031**	**0.092**	**0.279**	**0.02**
Low-tech	6.17	0.201	0.133	0.251	0.235	0.078	0.075	0.026	0.079	0.263	0.015
High-tech	1.513	0.29	0.2	0.34	0.302	0.167	0.142	0.054	0.146	0.347	0.04
National	7200	0.215	0.14	0.259	0.241	0.087	0.083	0.027	0.087	0.27	0.017
Foreign	483	0.368	0.238	0.412	0.372	0.2194	0.163	0.089	0.169	0.422	0.06

Source: DANE. (1) Product or process innovation. (2) New product or process to the firm. (3) New product or process to the market. (4) Organization or market innovation. (5) Technological or non-technological innovation. (6) Technological and non-technological innovation.

Some stylized patterns of how service firms innovate can be observed. The utmost result is that, contrary to what one could have expected, the percentage of service firms that introduced non-technological innovation was fewer than the percentage of firms that introduced technological innovation regardless of the origin of the capital or whether the firm provides knowledge-intensive services. The second major result is the fairly high percentage of innovative firms and firms having introduced non-technological innovations. For the whole sample of firms, almost 41 percent are innovative, and 28 percent were non-technological innovators. A third important innovation pattern is that, on average, the percentage of firm that introduced organizational innovation was *always* greater than the percentage of firms introducing marketing innovation. In a similar vein, for almost all service sectors, firms introduced more product than process innovations. When looking at the broadest measure of innovation, a fourth important fact emerges: 47 percent of firms introduced some kind of innovation, either technological or non-technological. Although the number of firms differs from one sector to the other, a simple non-weighted average shows that the percentages of innovating firms in all dimensions were greater for firms in knowledge-intensive sectors than in other service activities. One last but still important result is the comparison between the share of new-to-firm innovators and the new-to-market innovators. As expected, at least for a developing country, the new-to-firm innovators outnumber the new-to-the market ones.

The last five rows in Table 4 report results for the manufacturing sectors. Most of the patterns found for service firms also occur in these industries. For example, the percentage of firms that introduced technological innovation is greater than the percentage that introduced non-technological innovation regardless of the kind of capital or the technological level. Similarly, the share of product innovators is always greater than the share of process innovators; the share of organizational innovators outnumbers the share of marketing innovators; and the percentage of firms that introduced new-to-firm innovations is greater than the percentage of firms introducing new-to-the-market innovations.

Some inter-sectoral differences emerge. The most important ones are that service firms, on average, innovate more than their counterparts in manufacturing, no matter what the type of innovation. For example, the share of innovators in services is almost 14 percent greater than in manufacturing activities, and the share of non-technological innovators is about three times greater in services. One can conclude that service firms do innovate, innovate more than manufacturing firms, and do not innovate differently, as it is sometimes argued (Tether, 2005).

It is worth comparing the findings for Colombia with those in related research. Schmidt and Rammer (2007), for example, found that in Germany for the CIS4, 2002–2004, and for knowledge-intensive service activities, the share of non-technological innovators (66 percent) was higher than for either manufacturing industries (60 percent) or other service activities (48 percent). They also found that "the high shares of firms with non-technological innovations in particular in the service sectors are mainly driven by organizational innovations. Even in the manufacturing sector the share of firms with organizational innovations exceeds the share of the other three types of innovation" (Schmidt and Rammer, 2007: 9). They do not provide percentages. More recently, Sapprasert and Clausen (2012) found similar pattern for Norwegian firms. Using CIS4, they found that 37 percent of service firms were organizational innovators against 35 percent of organizational innovators in the manufacturing sector. Mothe and Nguyen Thi (2010) studied similar issues for Luxembourg firms using CIS4 and found that the share of organizational innovators in both the service and manufacturing sectors (77 percent) was higher than the share of marketing innovators (63 percent), and both shares were higher than the share of what they call "innovative firms" (41 percent, which appears to refer to product innovation only).

5.3. Decision to Invest in Innovation Activities

Table 5 presents the main patterns of decision making to invest in innovation activities in the service and manufacturing sectors. Some results between KIBS and traditional sectors are worth highlighting. First, in general, the average expenditure on innovation as a percentage of turnover is greater for knowledge-intensive service firms compared to non-knowledge-intensive ones. Additionally, the percentage of firms engaged in R&D activities is greater for KIBS compared with traditional counterparts. We can then state that KIBS firms are more prone to undertaking innovation than their non-KIBS peers. The second important fact is that the service firms, whether or not they are KIBS, decided to invest more in ICT than in R&D. The third fact is that there are small differences (always favoring foreign) between national and foreign firms when deciding to invest in innovation.

Table 5. Inputs and Outputs from Innovation *(Colombian Manufacturing and Service Sectors)*

		Inputs						Outputs	
	N	Expenditure on innovation	R&D	Machinery acquisition	ICT	Other innovation activities	Firms that performed R&D	Turnover from product innovations	Turnover from new to markets product innovations
		(1)	(2)	(3)	(4)	(5)		(6)	
All service industries	**3.662**	**0.046**	**0.126**	**0.326**	**0.269**	**0.243**	**0.212**	**0.102**	**0.034**
KIBS	616	0.054	0.203	0.355	0.214	0.229	0.299	0.188	0.063
Traditional	2.537	0.026	0.093	0.356	0.300	0.252	0.174	0.085	0.021
National	3.340	0.046	0.177	0.336	0.249	0.237	0.230	0.120	0.041
Foreign	322	0.055	0.224	0.258	0.267	0.242	0.191	0.105	0.025
All manuf. industries	**7.683**	**0.016**	**0.102**	**0.582**	**0.119**	**0.196**	**0.088**	**0.150**	**0.500**
Low tech	6.170	0.016	0.088	0.616	0.122	0.179	0.075	0.144	0.043
High Tech	1.513	0.018	0.144	0.475	0.111	0.267	0.138	0.189	0.068
National	7200	0.015	0.101	0.589	0.118	0.190	0.083	0.150	0.046
Foreign	550	0.026	0.162	0.532	0.126	0.234	0.185	0.240	0.080

Source: DANE-EDITs. (1) Total expenditure on innovation (as a percent of total turnover). (2) Expenditure on R&D as percent of total expenditure on innovation. (3) Expenditure on machinery acquisition as a percent of total expenditure on innovation. (4) Expenditure on ICT as a percent of total expenditure on innovation. (5) Expenditure on the rest of innovation activities as a percent of total expenditure on innovation. (6) Share of product innovation in turnover.

With regard to the manufacturing sector, some interesting findings should be noted. The first is that the percentage of foreign firms that invest in innovation activities is far larger than the percentage of national firms that do so. The second is that, as is the case for service activities, firms are more likely to engage in ICT activities than in R&D. Comparing the results of Table 5 between service and manufacturing firms, one finds different patterns of decision making about whether to invest in innovation activities. The most important one is that firms in service sectors, *on average*, spend, relatively to total turnover, more on innovation activities than manufacturing firms do. As expected, the difference is greater for the decision to invest in ICT. Service firms are supposed to use more technologies than manufacturing firms. Once more, Colombian service firms innovate and engage apparently more than their manufacturing peers.

What factors can explain the fact that service firms innovate more than manufacturing firms? Table 6 presents the main factors that may help to understand this pattern. Columns (2) to (4) report the percentage of firms that made use of cooperation with outside agents in order to achieve innovations or to undertake innovative activities: foreign partners, clients or providers, universities, or the government. In all three, firms in the service sectors, on average, had almost twice the number of linkages with outside agents as manufacturing firms. As was expected, the connections were greater in more advanced technological sectors, such as KIBS for services, and high-tech for manufacturers. Second, surprisingly, proportionally service firms entered into even more cooperation efforts in R&D than manufacturing companies. Third, although there has not been any innovation policy directed specifically at services industries, firms in these industries have profited, relatively, more from all the public support that the Colombian government has set aside for innovation purposes. Last, it has been argued (Djellal and Gallouj, 2010) and found (Rubalcaba, Gago, and Gallego, 2010) that service firms tend to make greater use of copyrights or confidentiality to protect their innovations than manufacturing firms make use of patents. This is also confirmed for Colombian service firms.

Table 6: Policy-related Variables *(Colombian Manufacturing and Service Sectors)*

	N	International markets	Cooperated with foreign partners	Cooperated with clients, providers	Cooperated universities or gov.	Any co-operation	Cooperated in R&D	Public support	Applied for patents
		(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
All service industries	**3.662**	**0.03**	**0.026**	**0.307**	**0.102**	**0.411**	**0.174**	**0.012**	**0.006**
KIBS	616	0.058	0.096	0.369	0.26	0.54	0.282	0.087	0.02
Traditional	2.537	0.021	0.015	0.275	0.08	0.379	0.118	0.007	0
National	3,340	0.009	0.08	0.344	0.247	0.503	0.274	0.033	0.022
Foreign	322	0	0.094	0.264	0.113	0.49	0.226	0	0.018
All manufacturing industries	**7.683**	**0.058**	**0.012**	**0.158**	**0.064**	**0.198**	**0.089**	**0.006**	**0.014**
Low-tech	6,170	0.048	0.009	0.145	0.055	0.184	0.077	0.005	0.017
High-tech	1.513	0.095	0.021	0.207	0.099	0.256	0.138	0.01	0.022
National	7200	0.048	0.01	0.148	0.058	0.185	0.080	0.005	0.012
Foreign	550	0.182	0.042	0.278	0.145	0.364	0.203	0.015	0.043

Source: DANE-EDITs. (1) Share of firms that export. (2) Share of firms that co-operated with foreign partners. (3) Share of firms that cooperated with clients and providers. (4) Share of firms that co-operated with Universities/Higher education or government research institutions. (5) Share of firms that cooperate with any. (6) Share of firms that co-operated in R&D activities. (7) Share of firms that received public financial support for innovation. (8) Share of firms that applied for one or more patents.

6. Methodology: The CDM Model

The CDM model (Crepon, Duget and Mairesse, 1998) is a multi-stage estimation procedure to determine the innovation drivers and its impact on labor productivity. The stages are as follows: firms decide to invest in innovation, then the amount of innovation is decided, new knowledge is produced, and then this knowledge is used in the firm's output. Implicit in the model is that knowledge is indeed used as an input in the firm's production function.

The equation that models the innovation decision is:

$$ID^{*} = w'\alpha + \epsilon \qquad (1)$$

where ID is a dummy variable that takes the value of 1 if the firm decided or reported to invest in innovation and 0 otherwise. ID* denotes the latent behavior of the variable when the decision to invest is above certain level c. w is a set of variables that explain the innovation decision.

The equation that models the innovation expenditure is:

$$IE^{*} = z'\beta + e \qquad (2)$$

IE^* is the innovation effort, measured as the innovation expenditure per worker. z is a vector of independent variables that explain the dependent one. This equation is only observed when the firm has invested, this is when ID=1. Under the appropriate conditions upon the error terms, both equations can be jointly estimated as a generalized Tobit model.

Once these models have been estimated, a knowledge production function is estimated:

$$TI = IE^{*}\,\gamma + x'\delta + u \qquad (3)$$

This production function has as output variable the knowledge outputs after the expenditure in innovation. x is a vector of other explanatory variables of the knowledge production.

Finally, the basic production function equation relates innovation to labor productivity. This is a production function for the firm's output in the usual fashion of a Cobb-Douglas production function:

$$y = \pi_1 k \; + \pi_2 TI + v \qquad (4)$$

Output and capital are expressed as per-worker values, and the knowledge output TI enters in levels to explain its impact upon labor productivity.

6.1. Specifications

In order to comply with the CDM model outlined in the previous section, the empirical specification undertaken for this study is described here. Equation (1), the decision to invest in innovation was estimated using the following set of variables:

$$ID^* = \; f(Exports, Foregin\ ownership, Patent\ protection, R\&D\ department, Size) \qquad (1A)$$

- ID: It is a dummy variable taking the value of 1 if innovation expenditure is positive; zero otherwise.
- $Exports$: It is a dummy variable taking the value of 1 if exports are positive; zero otherwise.
- $Foreign\ ownership$: It is a dummy variable taking the value of 1 if there is any foreign ownership; zero otherwise.
- $Patent\ protection$: It is a dummy variable taking the value of 1 if the firm obtained a patent as an industrial protection mechanism; zero otherwise. We only include Patent protection for the manufacturing industry.
- $R\&D\ department$: It is a dummy variable taking the value of 1 if the firm has a functioning or employee working in a R&D division within the firm, zero otherwise.
- $Size$: It is the number of the firm's employees, in natural logarithm.

Equation (2), the innovation investment intensity was estimated using the following set of variables:

$$IE^* = \; f(Exports, Foregin\ ownership, Patent\ protection, Public\ funding\ for\ innovation, Joint\ venture\ innovation, Market\ sources, Scientific\ sources, Public\ sources) \qquad (2A)$$

- IE: It is the firm's expenditure on innovation.
- $Exports$: It is a dummy variable taking the value of 1 if exports are positive; zero otherwise.

- $Foreign\ ownership$: It is a dummy variable taking the value of 1 if there is any foreign ownership; zero otherwise.
- $Patent\ protection$: It is a dummy variable taking the value of 1 if the firm obtained a patent as an industrial protection mechanism; zero otherwise.
- $Public\ funding$: it is a dummy variable taking the value of 1 if the firm was granted subsidies or credit from a government institution for innovation activities; zero otherwise.
- $Joint\ venture\ innovation$: it is a dummy variable taking the value of 1 if the firm undertook cooperation or non-financial joint venture with other firms in order to undertake innovation; zero otherwise.
- $Market\ sources$: it is a dummy variable taking the value of 1 if suppliers, clients, competitors, consulting firms and experts were important for new innovation ideas; zero otherwise.
- $Scientific\ sources$: it is a dummy variable taking the value of 1 if universities, public research centers, and technological institutions were important for new ideas; zero otherwise.
- $Public\ sources$: it is a dummy variable taking the value of 1 if newspapers, papers, conferences, Internet were important for new ideas; zero otherwise.

Equation (3), the knowledge production function, was estimated for technological innovation (TI) outcomes and non-technological innovation (NTI) outcomes, as they were defined in section 5, using the following set of variables:

$$TI\ and\ NTI = f(IE_{predicted}, Exports, Foreign\ ownership, size) \qquad (3A)$$

- TI: It is a dummy variable taking the value of 1 if there was a new good, service or process as the result from the innovation expenditure; zero otherwise.
- $IE_{predicted}$: The predicted value from equation (2A).
- $Exports$: It is a dummy variable taking the value of 1 if exports are positive; zero otherwise.
- $Foreign\ ownership$: It is a dummy variable taking the value of 1 if there is any foreign ownership; zero otherwise.
- $Size$: It is the number of the firm's employees, in natural logarithm.

Equation (4), the final output production function was estimated using the following set of variables:

$$y = f(TI_{predicted}, NTI_{predicted}, IE_{predicted}, K_{pc}, Exports, size) \qquad (4A)$$

- $TI_{predicted}$: The predicted value from equation (3A).

- $NTI_{predicted}$: The predicted value from equation (3A).
- $IE_{predicted}$: The predicted value from equation (2A).
- $Exports$: It is a dummy variable taking the value of 1 if exports are positive; zero otherwise.
- $Size$: It is the number of the firm's employees, in natural logarithm.

6.2. Descriptive Statistics of the Variables

Table 7 presents some descriptive statistics of the variables used in the CDM model. One key difference between this table and Table 6 is the smaller size of the sample of service firms finally included in the econometric exercises. Comparing the service and manufacturing sectors, we observe the same pattern of differences that were identified in Section 5. All of the indicators related to the innovation process are much larger for the service activities than for manufacturing sectors. This can be explained by the greater average size of service firms, almost three times larger. Having said that, a couple of facts are worth highlighting: First, service firms undertook more innovation activities, invested more, and consequently obtained more innovative results. Second, as reported in Table 6, service firms made more use of public financial support relatively to manufacturing firms. Table 7 shows that apparently the greater use could have been made mostly by SMEs, since now they are closer. Finally, Table 7 shows an indicator related to use of any industrial protection (of innovations), and reports that service firms do make use of some instruments other than patents.

Table 7: Descriptive Statistics of the Sample

	Service mean	**Manufacturing mean**
Amount of investment any innovation activity **(1)**	863	340
Amount of investment in R&D **(1)**	83	34
Amount of investment in physical capital **(1)**	113	28
Added value over size **(2)**	26	25
Size	290	96
Investment decision any activity	0.81	0.37
Investment decision in R&D	0.31	0.10
Non-technolgical innovation	0.51	0.09
Technological innovation	0.81	0.27
Patent protection	0.01	0.01
Co-operation in Innovation activities	0.45	0.19
Public financial support	0.02	0.01
Market source of information	0.64	0.31
Scientific sources of information	0.34	0.15
Public source of information	0.53	0.27
Research and development	0.26	0.12
Any industrial protection	0.35	0.25
Share of technician over workforce	0.24	0.14
Share of college over workforce	0.31	0.13
Observations	562	7,203

Source: DANE. (1) Amount of Investment in 2008 $US of 2008. (2) Added value by size in 2008 US$.

7. Results

7.1. Innovation and Productivity in the Manufacturing Industry

7.1.1. The Decision to Invest in Innovation and the Intensity of the Innovation Expenditure

Table 8 presents the estimation results for the decision to invest and the intensity of innovation for the manufacturing sector. The results are presented in four panels, one for the overall sample of firms, and three other panels of manufacturing firms grouped by the technological development: high, medium, and low. Each panel shows the decision to invest (DI) and intensity to invest (IE) estimation.

First, regardless of the technological level of the industry, there is a remarkably similarity in the signs of coefficients across results for both equations. This is particularly true for the decision to invest, where all the signs were the same although the statistical significances differ. Second, the propensity to engage in innovation activities increases as firms perform some kind of

R&D. This result is very important since it signals, as we will comment later, that some kind of persistency is present for firms undertaking innovation investment decision. Whether there is an R&D department on the firm's premises or the firm employs people to work on R&D activities, R&D investments are costly and are only undertaken by firms committed to investing in innovation for long periods of time. Otherwise, they will not be able to recover the investment.

Third, some unexpected results were found. For instance, for the whole sample, firms that export have about a 6 percent lower probability of investing in innovation, and that percentage increases in low-technological manufacturing industries to about 7 percent. The high-technological industries have also negative coefficient, but it is not statistically significant. One explanation of this finding could be that the manufacturing sector has lost its importance as a driver of the Colombian economy, and that the main Colombian exports are from the primary sector, including coal, oil, or agricultural goods: bananas, coffee and flowers, that are not intensive in technology use. Then, it is important to see whether in economies suffering from Dutch disease, innovation in manufacturing industries presents declining trends. It is important to highlight this result since Crespi and Zuñiga (2012) found a positive and significant correlation.

Despite being negatively correlated to the *decision* to invest, firms that export indeed invested more in innovation than their non-exporting peers. This result is strong across the different clusters. One potential hypothesis is that exporting firms might have been exporting for a long period of time and they need to maintain their innovation expenditure to keep competing in those more demanding markets. After being persistent exporters, to satisfy external clients' demands for innovative goods, they need to keep up their investment standard. It may be that persistent exporters are also persistent innovators (from the output side of the innovation process). A longer span of innovation data is needed to test this explanation.

An expected finding is that foreign ownership, regardless of whether the industry is low- or high-tech, shows a negative coefficient. This means that the foreign ownership implies a lower propensity to innovate. The results are statistically significant for the full sample and for the low-tech industries. This finding was also reported in previous studies (Raffo, Lhuillery and Miotti, 2008, for Spain and Brazil) and Crespi and Zuñiga (2012) argue that in developing countries, foreign firms perform innovation activities if internal markets are large enough or if they have some national innovative attractiveness; otherwise they will just use their external technological assets.

The use of mechanisms to protect innovations, such as patents and the like, positively affected the propensity of firms to undertake innovative activities. The signs of all three regression groups are positive and statistically significant. This result, once more, signals the persistency in innovation by manufacturing industries since, arguably, only firms that have carried out innovation efforts in the past keep looking for ways to protect those investments. Again, a longer span of data would be needed to test formally this argument.

Another unsurprising result, highly analyzed in the innovation research, is the size effect, as can be seen in Table 8. For all firms and the corresponding subgroups, the bigger a firm is, the higher its probability and intensity to innovate. The size of the coefficient is almost four times larger than the one found for Colombian firms (Crespi and Zuñiga, 2012).

Investment in innovation is greater for firms that received public financial support and that cooperated in innovative activities. This is a very important finding. First, the coefficient of public financial support is 0.50, highly significant, although it is 0.3 lower than the coefficient reported by Crespi and Zuñiga (2012). The statistical significance is lost for the three groups in which the whole sample was split. The size and statistical significance of this coefficient for all firms shows that firms investing in innovative activities regard public financing as a potential supplement to the internal funds.

Cooperation in innovation, for all firms and those in the high and medium technology levels, continues to be an important factor that boosts investment in innovation, as was also found in a previous study (Crespi and Zuñiga, 2012). It is interesting to see that low-technology firms do not seem to have undertaken cooperative endeavors, perhaps due to the fact they can be doing incremental or small innovations so they may not need to enter in formal agreements.

Another variable that also had the expected positive coefficient and is highly significant for the whole sample is the market information source with a coefficient of 0.32, a bit lower than the 0.51 reported by Crespi and Zuñiga (2012). It may indicate that Colombian manufacturing firms that appear to be making use of this source of information (i.e., suppliers, clients, competitors and experts) invest more in innovation. Finally, the other two sources of innovations did not affect innovation investment. Besides these set of results, a full set of results was also obtained in a specification that drops the R&D variable. The findings were identical in signs and statistical significance. The interested reader can request these from the authors.

Table 8. CDM Model in Manufacturing -Stage 1: Decision to Invest in Innovation and Intensity of Innovation Expenditure per Employee

	All		**Low tech**		**High tech**	
	log(investment any innovation activity)	Decision to invest in any activity	log(investment any innovation activity)	Decision to invest in any activity	log(investment any innovation activity)	Decision to invest in any activity
	1	2	3	4	5	6
Exporting	0.524***	-0.0663*	0.524***	.-0.0743*	0.600***	-0.0647
	(0.0935)	(0.0386)	(0.112)	(0.0440)	(0.168)	(0.0825)
Foreign ownership	1.123***	-0.224***	0.952***	.-0.262***	1.534***	-0.173
	(0.141)	(0.0613)	(0.176)	(0.0730)	(0.226)	(0.118)
Patent protection	-0.244	0.489***	.-0.131	0.449***	-0.387	0.518**
	(0.250)	(0.117)	(0.330)	(0.143)	(0.350)	(0.218)
Public financial support	0.503**		0.525**		0.394	
	(0.226)		(0.254)		(0.710)	
Cooperation in innovation activities	0.278***		0.240***		0.373***	
	(0.0746)		(0.0887)		(0.139)	
Market source of information	0.324***		0.429***		-0.0701	
	(0.0776)		(0.0887)		(0.168)	
Scientific sources of information	0.0589		0.0434		0.117	
	(0.0840)		(0.0990)		(0.151)	
Public source of information	0.00151		0.0174		0.00858	
	(0.0783)		(0.0918)		(0.154)	
Research and development		**0.565*** **		**0.518*** **		**0.670*** **
		(0.0503)		**(0.0603)**		**(0.0922)**
Size		0.418***		0.413***		0.440***
		(0.0124)		(0.0139		(0.0302)
Observations	7,203	7,203	5.761	5.761	1,442	1,442

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

7.1.2. The Knowledge Production Function and its Determinants

Table 9 presents the results of the estimation of the knowledge production function, with dummy variables for technical (product or process) and non-technical (organizational and marketing) innovation used as dependent variables. We estimate these equations with a bivariate probit model, controlling for the correlation between the variables in the error term. Panel A in Table 9 shows the coefficients of the bivariate probit regressions, and Panel B shows the joint probability of doing both non-technological and technological innovation estimated at the sample means of the explanatory variables.

The results show that innovation in output is determined to be positively and statistically significant by investments in innovation inputs. As was explained in the CDM model, the predicted values for innovation investments are obtained from the previous stage—the innovation expenditure equation (stage 1 in Table 8). The predicted innovation expenditure increases the joint probability of a firm to have both types of innovation in 21.5 percent approximately, and this probability is higher in the high-tech sectors than in the low-sectors. The impact of innovation inputs is large compared to the probabilities of innovation given the size. The result seems to show that there are larger economies of scale and scope in the knowledge production function by firms in high-tech manufacturing. On the other hand, being an exporter and having foreign ownership reduce the probability of introducing either type of innovation. These results hold for the whole sample of firms as well as for the high- and low-tech sectors.

Table 9. Panel A: Stage 2 - Knowledge Production Function in Manufacturing

	All manufacturing		Low-tech		High-tech	
	Technological	**Non-technological**	**Technological**	**Non-technological**	**Technological**	**Non-technological**
IE_p (predicted innovation expenditure per employee)	2.489***	2.194***	2.160***	1.781***	0.315***	0.210***
	(0.0690)	(0.0832)	(0.0830)	(0.106)	(0.0363)	(0.0396)
Exporting	-1.319***	-0.987***	-1.092***	-0.644***	-1.077***	-1.104***
	(0.0583)	(0.0697)	(0.0735)	(0.0910)	(0.145)	(0.153)
Foreign ownership	-2.845***	-2.532***	-2.217***	-1.966***	-3.530***	-3.687***
	(0.103)	(0.122)	(0.130)	(0.165)	(0.346)	(0.348)
Size	0.224***	0.131***	0.221***	0.146***	2.071***	2.180***
	(0.0165)	(0.0203)	(0.0212)	(0.0271)	(0.204)	(0.204)

Panel B: The Joint Probability of Technological and Non-technological Innovation Activities

	All	Low-tech	High-tech
IE_p (predicted innovation expenditure per employee)	0.215***	0.154***	**0.421*** **
	(0.0098)	(0.0089)	**(0.0387)**
Exporting	-0.069 ***	. -0.049***	-0.184***
	(0.0041)	(0.0036)	(0.0205)
Foreign ownership	-0.064***	- 0.042***	-0.221***
	(0.0034)	(0.003)	(0.0163)
Size	0.013***	0.011***	0.041***
	(0.0016)	(0.0015)	(0.0072)
Observations	7,203	5,761	1,442

7.1.3. The Impact of Innovation on Productivity

Table 10 shows the findings of how innovation, technological and non-technological, impacts average labor productivity in manufacturing firms. The main result, in line with the findings in studies for developed and developing countries (Crespi and Zuñiga, 2012; Griffith, Huergo, Mairesse, and Peters, 2006; OECD, 2009), is that innovations positively affect (with statistical significance) labor productivity. The effect of non-technological innovations is marginally larger than for technological innovations in any of the specifications.

The magnitudes of the semi-elasticities, 0.14 and 0.19 for the full sample of 7,203 firms, are smaller than the previous one found by Crespi and Zuñiga for the Colombian manufacturing firms. They are also smaller with respect to the findings reported by Criscuolo (OECD, 2009) for product innovation, but closer to those reported by Griffith et al. (2006) for either product or process innovations. Introducing either type of innovations increases average productivity by between 14 and 19 percent. For a robustness check, a secondary specification where the reported non-technological innovations instead of the estimated one were used shows similar values. The table also shows that the greater the predicted innovation intensity (investment per employee) the higher the productivity is. Last, when splitting the full sample by technology intensity, firms in low-technological industries show higher, more statistically significant coefficients. In the case of firms in high-tech sectors, the statistically significance is lower than the low-tech ones and the whole industry.

In summary, the main results for manufacturing are as follows: first, both types of innovations matter for firm labor productivity, for the full sample as well as for low- and high-technological firms. Second non-technological innovation affects firm productivity more than technological innovation.

Table 10. CDM Model in Manufacturing, Stage 3: Impact of Innovation on Labor Productivity

	All				Low tech				High tech			
	Value added per employee				Value added per employee				Value added per employee			
	1	2	3	4	5	6	7	8	9	10	11	12
TI_p (predicted of technological innovation)	**0.141*** **			**0.110*** **	**0.130*** **			**0.100*** **	**0.116* **			**0.0879**
	(0.0187)			**(0.0199)**	**(0.0205)**			**(0.0216)**	**(0.0657)**			**(0.0693)**
NTI_p (predicted of non-technological innovation)		**0.190*** **				**0.210*** **				**0.125* **		
		(0.0214)				**(0.041)**				**(0.0641)**		
IE_p (predicted innovation expenditure per employee)			0.509***				0.438***				0.463***	
			(0.0247)				(0.0296)				(0.0443)	
Investment per employee	0.286***	0.285***	0.286***	0.288***	0.166***	0.163***	0.166***	0.166***	0.303***	0.301***	0.296***	0.297***
	(0.029)	(0.026)	(0.023)	(0.024)	(0.014)	(0.013)	(0.015)	(0.014)	(0.0302)	(0.030)	(0.0301)	(0.0304)
Size	0.120***	0.117***	0.0588***	0.123***	0.123***	0.117***	0.0768***	0.124***	0.114***	0.122***	0.0139	0.118***
	(0.0116)	(0.0111)	(0.0105)	(0.0115)	(0.0126)	(0.0121)	(0.0125)	(0.0115)	(0.0327)	(0.0284)	(0.0250)	(0.0328)
Non-technological innovation				0.188***								0.104
				(0.0424)								(0.0808)
Observations	7,203	7,203	7,203	7,203	5.761	5.761	5.761	5.761	1,442	1,442	1,442	1,442

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

7.2. Innovation and Productivity in the Service Sector

The previous section argues that Colombian service firms do innovate and that apparently the percentage of innovating firms is greater than the percentage of innovating peer firms in manufacturing.[6] The reader should bear in mind that the EDIT-2 collects data for a sub-sample of firms that is largely different from the sample of firms in the EAS. It is then only possible to get a reduced match of firms between those two surveys. The sample of matched firms that enters into the regression analysis is about 562 firms. This small number of firms may lead to have lower goodness of fit as well as to obscure a bit the real effect of the explanatory variables. With that in mind, we next present the results of the CDM exercise for that sample of firms, following the same econometric procedures explained previously, and then proceed to describe the main differences with respect to the manufacturing industry. It is important to note that one difference with the manufacturing sector exercise is that the regressions do not include a dummy variable of the firm exports because this information is not available for the service sector. In addition the specification does not include patent protection because only a few service firms use this mechanism; thus, to include it does not help to discriminate among firms.

Table 11 presents the estimation results for the first stage using data from firms in the service sectors. The first finding we would like to highlight is the positive impact of the R&D variable on the decision to undertake innovation. Although significant at 10 percent, the result is very important, since literature on innovation in service has tended to lessen the importance of R&D in the service sector (see Musolesi and Huiban [2011], who also found a positive relation of their indicator of R&D in the innovation function for French service industries). The statistical significance of this variable is lost when the sample of service firms is divided between knowledge-intensive business service (KIBS) and no-KIBS. This result may be due to the small number of firms in those two groups, which may reduce the variability.

Two caveats emerge. The first one is that the measurement of R&D is not ideal, and the second is that the number of firms is small. Therefore, one should be wary to generalize this

[6] As mentioned previously for the manufacturing sector, DANE collects data for (roughly) all manufacturing firms while for the service industry, it samples firms randomly.

result to the whole Colombian service sector. Large firms have a higher propensity to innovate than smaller ones, a result that holds for both KIBS and no-KIBS firms. Previous studies of European countries (Mairesse and Robin, 2009; Musolesi and Huiban, 2011) also found a positive impact of size on service firms' decision to innovate.

The propensity to undertake innovation by service firms is not affected by the nature of the capital or by the mechanisms used to protect innovations, at least for the full sample of firms. The sign is positive in both cases, however not statistically significant. For non-KIBS firms, foreign capital presence seems to be important in increasing the probability of undertaking innovative activities. One potential explanation is the ample presence of multinational firms in the Colombian retail and whole trade sub-sector. However, the investment per employee in innovation activities is greater for firms with foreign capital. With regard to the intensity of innovation, service firms, which received public funding, cooperated in innovation activities and used market sources of information, which deepened their investment intensity in innovative activities.

Table 11. CDM Model in Services -Stage 1: Decision to Invest in Innovation and Intensity of Innovation Expenditure per Employee

	All services		**KIBS**		**Traditional**	
	log(investment any innovation activity)	Decision to invest in any activity	log(investment any innovation activity)	Decision to invest in any activity	log(investment any innovation activity)	Decision to invest in any activity
	1	2	3	4	5	6
Foreign ownership	1.33***	0.254	1.034***	0.446**	1,298	
	(0.367)	(0.259)	(0.367)	(0.219)	(1.290)	
Public financial support	1.916***		1.617***		1,702	
	(0.720)		(0.741)		(2.912)	
Co-operation in innovation activities	0.620***		0.425**		0.363	
	(0.200)		(0.228)		(0.378)	
Market source of information	0.339		0.339		0.609	
	(0.244)		(0.312)		(0.467)	
Scientific sources of information	0.288		0.587		-0.543	
	(0.236)		(0.266)		(0.437)	
Public source of information	0.376		0.220		0.654	
	(0.244)		(0.283)		(0.444)	
Research and development		0.401**		0.325		0.158
		(0.165)		(0.221)		(0.436)
Size		0.289***		0.239***		0.459***
		(0.039)		(0.049)		(0.101)
Observations	562	562	352	352	210	210

Results for the knowledge production function for both the technological and non-technological innovations are presented in Table 12. As with manufacturing, Panel B presents the joint probability to innovate in technological and non-technological activities. The general view is that the determinants of both types of innovations do not differ at all in their effects. With respect to the effect of the predicted innovation expenditure on either type of innovation (technological and non-technological), the estimated probability is positive, as expected, statistically significant, and makes perfect economic sense. They show that a predicted greater innovation effort per employee leads to a higher probability of having more technological and non-technological innovations. With respect to foreign ownership, the coefficient is negative, meaning that service firms with foreign capital tend to innovate less, more on the technological side of innovations than the non-technological. Finally, size does not seem to be an important determinant of the probability of introducing innovations. When analyzing the two groups of KIBS and no-KIBS firms, few differences are found in their estimated effects and significance. However, the magnitude of the effects is different. For KIBS firms, the probability of introducing either type of innovation is economically much higher, meaning that these firms may have greater economies of scale and scope in the knowledge production function.

Table 12. Panel A: Stage 2 - Knowledge Production Function in Services

	All manufacturing		Low-tech		High-tech	
	Technological	**Non-technological**	**Technological**	**Non-technological**	**Technological**	**Non-technological**
IE_p (predicted innovation expenditure per employee)	0.780***	0.432***	0.430**	0.384**	1.066***	0.387***
	(0.104)	(0.0708)	(0.175)	(0.155)	(0.206)	(0.114)
Foreign Ownership	-0.722***	-0.360*	-0.292	0.142	-0.891***	-0.212
	(0.276)	(0.204)	(0.670)	(0.573)	(0.343)	(0.234)
Size	0.0771	0.0371	0.0816	-0.0182	0.0639	0.0764
	(0.0473)	(0.0370)	(0.100)	(0.0857)	(0.0631)	(0.0474)

Panel B: Joint Probability of Technological and Non-technological Innovation Activities

	All	**Low-tech**	**High-tech**
IE_p (predicted innovation expenditure per employee)	0.225***	0.221***	**0.201****
	(0.021)	(0.041)	(0.054)
Foreign Ownership	-0.198***	-0.152**	-0.0321
	(0.061)	(0.083)	(0.189)
Size	0.0227*	0.0298	0.0152
	(0.0137)	(0.0180)	(0.0299)
Observations	684	352	210

Table 13 provides the results of the productivity equation. An important finding is that firms that innovate in either type of innovation have greater labor productivity. The economic impact is about 0.20 higher for non-technological innovations. These results hold for KIBS firms, while for the non-KIBS firms, the coefficients have the expected sign and some economic significance, but are not statistically significant.

Turning to the impact of the (estimated) expenditure per employee in innovation, and for the purpose of checking the robustness of the previous commented results, we obtained expected results with high economic and statistic significance for both the full sample and for KIBS firms.

Table 13. CDM Model in Services, Stage 3: Impact of Innovation on Labor Productivity

	All services log added value per employee				KIBS log added value per employee				Traditional log added value per employee			
	1	2	3	4	5	6	7	8	9	10	11	12
TI_p (predicted of technological innovation)	0.323* (0.123)		0.258* (0.118)		0.361** (0.149)		0.367** (0.157)		0.0785 (0.270)		0.109 (0.274)	
NTI_p (predicted of non-technological innovation)		0.555*** (0.208)				0.602*** (0.316)				0.138 (0.271)		
IE_p (predicted innovation expenditure per employee)				0.268*** (0.082)				0.351*** (0.130)				0.009 (0.110)
Investment per employee	0.236*** (0.023)	0.234*** (0.023)	0.237*** (0.023)	0.231*** (0.023)	0.333*** (0.0332)	0.331*** (0.033)	0.326*** (0.0331)	0.327*** (0.0334)	0,0639*** (0.0236)	0,0636*** (0.0236)	0,0637*** (0.0236)	0,0634*** (0.0237)
Size	-0.137*** (0.047)	-0.146** (0.0475)	-0.138** (0.047)	-0.135** (0.045)	-0.191*** (0.061)	-0.211*** (0.0648)	-0.197** (0.068)	-0.185** (0.066)	-0.0930 (0.0706)	-0.0883 (0.0586)	-0.0953 (0.0708)	-0.0893 (0.0598)
Non-technological innovation			0.166 (0.124)				0.343 (0.174)				-0.0908 (0.131)	
Observations	562	562	562	562	352	352	352	352	210	210	210	210

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

7.3. Do Innovation-Productivity Relations Differ (significantly) across Service and Manufacturing Firms?

One of the key results in the analysis of the two preceding sections is that service firms engage in innovation more than manufacturing firms do. Then, a question arises: do they exhibit a different relationship between innovation and productivity? To answer this question, we will use the results presented in Table 8 to Table 13. The answer will be reported by comparing the differences at every stage of the development-line decision-to-invest to productivity-equation.

The first stage presents the determinants of the decision to invest and the intensity of innovations, and in both equations the variables R&D activities and size are key determinants. The propensity to engage in innovation is, however, almost twice as high for manufacturing firms than for service firms. The most probable explanation may be the difference in the samples of firms. As already noted, manufacturing data include a high number of firms, compared to the service data, which is only a reduced sample. The goodness of fit tends to be better and the variability higher the larger the number of firms. On the other hand, while foreign ownership and patent protection were highly significant for the manufacturing firms' decision to invest, they were not for the service firms'. One explanation for the second variable may be the lower propensity of service firms to make use of those mechanisms since service firms' output is intangible and most of the time tailor-made. Similarly, the intensity of investment in innovation is affected positively and is highly economically and significantly statistically in both economic sectors by foreign ownership, public financial support, and market source of information. However, in this case, the impact of these variables is higher for service firms, especially for the first two of them. The remaining variables are not statistically significant.

The comparison of the knowledge production functions shows also some similar patterns. First, the larger the investment per employee is, the higher is the probability that firms introduce innovations, both technological and non-technological. However the joint probability is similar for both manufacturing and service sector, but with higher probability at the technological manufacturing sector. Foreign ownership is negatively correlated with the introduction of innovations for firms in both industries.

Last but not least, firms that introduced any type of innovation are paid off with greater average labor productivity regardless of whether they belong to manufacturing or services. And contrary to the results in the knowledge production function, the introduction of innovations leads to much higher productivity in service firms.

7.4. A Further Extension of the CDM Model of Innovation

The core CDM model of innovation presented in the previous section has shown very key results. The model, however, can be extended to include variables that were omitted for purposes of allowing comparisons across countries. Among the variables that research on innovation has included are: human capital, a firm's belonging to a conglomerate or economic group, degree of competition the firm faces in the national market, the level of market concentration, a net or gross level of profits, the corporate governance of the firm, and more recently, ICTs, among others. In what follows, we present a key extension of the model, by introducing two measures of human capital, right from the start of stage one in the extended CDM model. Our rationale is, first, to explore whether including human capital changes the results significantly, and specifically, if human capital would reduce the importance of R&D in determining the decision to invest, which may suggest some interchangeability between those two variables; and second, to see the differentiated effects of the two indicators of human capital, each one aiming, one could argue, at different but perhaps complementary influences on the innovation process.

Tables 14 and 15 present the results of the decision to invest and intensity of innovation equations of the stage 1 (first) panel for both the manufacturing and service industries. Some key changes appear. The results for the manufacturing industries are kept, so that sign and statistical significance are the same. There are marginal changes in the size of the coefficients. With regard to the impact of the human capital variables, they are positive, with *high economic impact* on the decision to innovate and highly significant. Regarding the magnitude of the two variables, we observe that the proportion of employees with a university degree is higher, as one might expect, than the number of employees with a technical degree. The R&D-lab variable is still significant and positive, and the coefficient is similar to that in Table 8. Since the R&D indicator is a dummy variable, it can only imprecisely capture the real meaning of R&D. The introduction of these two human capital variables can help to disentangling the relationships across the model.

Table 14. Including Human Capital Composition of the Labor Force - Manufacturing

First stage

	1	2
	Iog(investment any innovation acitivity	**Decision to invest in any activity**
Exporting	0.558***	-0.097***
	(0.0899)	-0.036
Foreign ownership	1.093***	-0.319***
	(0.141)	(0.0605)
Patent protection	-0.312	0.472***
	(0.278)	(0.131)
Public financial support	0.600***	
	(0.194)	
Cooperation in Innovation	0.249***	
	(0.0699)	
Market source of information	0.366***	
	(0.0764)	
Scientific source of information	0.0290	
	(0.0784)	
Public source of information	0.0405	
	(0.0771)	
Technician		0.331***
		(0.075)
College degree		0.832***
		(0.103)
R&D		0.466***
		(0.051)
Size		0.505***
		(0.0120)
Observations	7203	7203

Second stage (knowledge equation)

	3	4	5
	TI	**NTI**	**Joint Probability to innovation TI and NTI**
		coeficients	
IE_p	2.353***	2.018***	0.224***
	(0.0644)	(0.0785)	(0.0105)
Exporting	-1.410***	-1.027***	0.0961***
	(0.0559)	(0.0677)	(0.0051)
Foreign Ownership	-2.698***	-2.388***	-0.0694***
	(0.0979)	(0.117)	(0.0034)
technician	0.216**	0.292**	0.02898**
	(0.0977)	(0.128)	(0.0102)
college	0.656***	0.849***	0.07315***
	(0.129)	(0.159)	(0.01293)
Size	0.262***	0.173***	0.01587***
	(0.0162)	(0.0197)	(0.00171)
Observations	7203	7203	

Third stage (productivity equation)

	6	7	8	9
	Added value per employee			
TI_p	0.0346**			0.0172
	(0.0173)			(0.0183)
NTI_p		0.0577***		
		(0.0202)		
Investment	2.56e-06***	2.55e-06***	4.15e-06***	2.56e-06***
	(2.16e-07)	(2.16e-07)	(3.45e-07)	(2.16e-07)
technician	0.537***	0.522***	0.463***	0.532***
	(0.0584)	(0.0588)	(0.0591)	(0.0584)
college	1.863***	1.818***	1.718***	1.847***
	(0.0771)	(0.0796)	(0.0795)	(0.0773)
Size	0.190***	0.186***	0.111***	0.191***
	(0.0111)	(0.0107)	(0.0104)	(0.0111)
IE_p			0.316***	
			(0.0217)	
NTI				0.113***
				(0.0394)
Observations	7203	7203	7203	7203

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

In the case of the service industries, coefficients were similar to those in manufacturing, but the statistical significance of the human capital variables is lost. The R&D is still significant for service industries. Further research is needed to have more robust results. First, the number of firms in the service CDM model is relatively low, and second, a better indicator of R&D can be constructed. In any case, human capital indicators can do better at removing any scale problems present in the data than a dummy variable.

The above is reinforced after looking at the other two stages where the two human capital indicators were included. For manufacturing, the two variables also happen to be highly statistically significant and do not change the signs and statistical significance of the other main explanatory variables. The magnitudes of the estimated innovation decisions, intensity investments, and estimated innovations do vary, but this may indicate that they are picking up or disentangling better the inner relationships among key forces in the innovation process. For the service industry, the two indicators do not change the existing results, but their influences on both the knowledge production function and the productivity equation are somewhat weak. It is worth highlighting that the proportion of employees with university degrees has a significant economic impact on service firm productivity.

Table 15. Human Capital Composition of the Labor Force - Services

	First stage		Second stage (knowledge equation)			Third stage (productivity equation)			
	1	2	3	4	5	6	7	8	9
	log_IE	IE_D	TI	NTI	Probability to innovation TI and NTI	log_vasize	log_vasize	log_vasize	log_vasize
Foreign ownership	1.348***	0.300	-0.725***	-0.374*	-0.213***				
	(0.349)	(0.253)	(0.277)	(0.204)	(0.0658)				
Public financial support	1.865***								
	(0.418)								
Co-operation in innovation	0.512***								
	(0.180)								
Market source of information	0.386*								
	(0.220)								
Scientific source of information	0.263								
	(0.208)								
Public source of information	0.337								
	(0.218)								
Research and development		0.357***							
		(0.043)							
Technician		0.204	0.0875	-0.382	0.0842	0.250	0.295	0.544*	0.291
		(0.286)	(0.289)	(0.247)	(0.2876)	(0.299)	(0.300)	(0.313)	(0.301)
college		0.23	-0.0190	0.0568	-0.02002	0.783***	0.844***	0.803***	0.845***
		(0.242)	(0.206)	(0.170)	(0.2024)	(0.207)	(0.206)	(0.210)	(0.206)
Size		0.287***	0.0756	0.0421	0.0244	-0.0888*	-0.0837*	-0.0854*	-0.0836*
		(0.0363)	(0.0475)	(0.0372)	(0.0138)	(0.0454)	(0.0475)	(0.0476)	(0.0475)
IE_p			0.762***	0.471***	0.2408***	0.300***			
			(0.115)	(0.092)	(0.02941)	(0.0806)			
TI_p							0.306***		0.312***
							(0.107)		(0.110)
NTI_p								0.580***	
								(0.201)	
Investment						0.236***	0.234***	0.237***	0.235***
						(0.023)	(0.023)	(0.023)	(0.023)
NTI									-0.0285
									(0.123)
Observations	562	562	562	562	562	562	562	562	562

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

In conclusion, the extension of the core CDM model to include human capital sheds light on its importance and the potential interchangeability with the R&D indicator. One main reason is that these variables are not dummies; therefore, they remove any scale problem present in the data, which the R&D dummy cannot do. The importance of both variables in manufacturing and services is set, although it appears, in our research, to be more important for the former than for the latter. More research is warranted.

7.5. Lessons from the Study

Table 16 summarizes the lessons learned from this study on innovation in the service and manufacturing sectors. Clearly, the key lesson is that firms that engage in innovation processes and that invest more proportionally to their sales have better chances of introducing both technological and non-technological innovations into the market or within the firm; and by introducing *any kind* of innovation, these firms end up with greater labor productivity. Hence, it pays off to engage in efforts to innovate. But to engage in those activities, the other lessons this research highlights is that (a) firms with a higher shares of employees with college and technical degrees are more likely to engage in innovation and to have higher productivity; (b) firms that make use of private and public sources of information can increase their chances to get innovation outcomes; (c) firms that use more public financial resources can implement better innovation strategies; and (d) firms that are more export oriented can exploit, potentially, greater economies of scale and grasp more and better ideas.

Table 16. Lessons from Research on Innovation in Manufacturing and Services		
Impact on Innovation from	**Industry**	
	Manufacturing	**Services**
The degree of knowledge accumulation	Very important: human capital stock, as well as investment in R&D labs, are critical factors that deepen firms' investment in innovative activities. Furthermore, firms with larger shares of employees with college degrees have greater productivity. Share of employees with technical degrees also impacts productivity.	Relatively important: firms that invested in R&D labs were more prone to increase the intensity of innovation. Human capital was relatively much less important.
The capacity to protect intellectual property	Very important: Firms use this protection device more frequently. Its importance in the decision to undertake innovative efforts is shown in the first stage of the innovation process.	Not frequently used: Firms rarely use too much patents to protect their inventions. Other mechanisms, such as copyrights and confidentiality, are used. No impact on the decision to innovate.
The relevance of market sources of information (spillovers)	Very important: These sources of information are clearly determinants of having more intensity in the innovation.	Very important: These sources of information are clearly determinants of having more intensity in the innovation.
The relevance of public sources of information (spillovers)	Not important: These sources of information were positively associated with the intensity of innovation although they had no statistical effect.	Fairly important: A greater impact on the intensity of innovation expenditure but not statistically significant.
Formal linkages for innovation (cooperation variables)	Very important: Firms that cooperated with external agents--clients, universities, or providers--increased their intensity of innovation.	Very important: Firms that cooperated with external agents--clients, universities, or providers--increased their intensity of innovation.
Fixed costs (size)	Very important: Size of the firm is a vital variable for engaging in innovative projects.	Very important: As in manufacturing, larger firms tend to be more prone to innovate.

Financing (public support)	Very important: Manufacturing firms that made use of public financial support increased their intensity of innovation expenditure.	Very important: As in manufacturing, the intensity of innovation expenditure was propelled by the use of public financial resources.
Trade integration	Very important: Firms that sell abroad increase their intensity of innovation and are more likely to have joint technological and non-technological innovations.	Not used: Firms in the sample happened not to sell abroad. Therefore, this variable did not affect either their decision to invest or their innovative outcome.
The effects of innovation investments on productivity and the transmission mechanism (technological vs. non-technological innovation)	Direct and strong links between the innovation expenditure and the innovation outcomes and between these and firm productivity. The higher the intensity of innovation, the greater the likelihood of introducing both technological and non-technological innovations. And the higher the probability of innovation, the greater the average labor productivity of the firm. Therefore, it pays off to innovate.	Direct and stronger links between innovation expenditure and innovation outcomes and between these and firm productivity. The higher the intensity of innovation, the greater the likelihood of introducing both technological and non-technological innovations. And the higher the probability of innovation, the greater the impact on the labor productivity of the firm. Therefore, it pays off to innovate.

8. Obstacles to Innovating

Table 17 shows the statistics for the obstacles faced by manufacturing and service firms when they undertake innovation. Several patterns can be observed. In general, whether for manufacturing or services, obstacles related to risk seem to be somewhat greater than other obstacles for innovators. These same obstacles are one or two percentage points greater for the more technologically advanced sectors. Second, regardless of the industry, it is clear that managers or owners of the firms see the innovation process as very risky, which helps explain the relatively low levels of innovation intensity of Colombian firms compared to firms in other countries.

Two factors that were critical in explaining greater involvement of firms in innovation, that is, human capital and public financial resources, are also two of the main obstacles to engaging in innovation activities: lack of a firm's own resources and lack of skills. Public policy can reduce the impact of these factors. COLCIENCIAS could offer better financial products to address the lack of financial resources or could do a better job promoting its existing products; SENA and COLCIENCIAS could put projects in place to help alleviate the lack of qualified employees. There is also room for universities and research centers to engage in more collaborative and specific innovation projects with firms that do not have the organizational structure to handle a larger labor force or to hire more workers but are willing to innovate. Third, for both manufacturing and service firms, obstacles linked to external conditions were ranked the least important. The most intriguing are related to the protection of innovation outcomes. Firms perceived low risk that other firms might copy their innovations and believe that there is little institutional capacity to protect them.

Table 17

Panel A: Obstacles to Implementing Innovation in anufacturing	All Manufacture		Low Tech		High Tech	
	Innovators	No-innovators	Innovators	No-innovators	Innovators	No-innovators
Obstacles linked to internal capacity and information						
Lack of own resources	0.40	0.44	0.40	0.44	0.42	0.46
Lack of skill workers	0.41	0.51	0.41	0.51	0.39	0.53
Problems to achieve regulation and technical requirements	0.34	0.45	0.34	0.45	0.37	0.44
lack of information about markets	0.40	0.52	0.39	0.51	0.42	0.55
Lack of information about available technology	0.40	0.52	0.39	0.53	0.41	0.52
Lack of information about public policies to support innovation	0.34	0.46	0.33	0.45	0.35	0.49
Obstacles linked to risk						
Uncertainty about demand on goods and services	0.42	0.46	0.42	0.45	0.42	0.49
Uncertainty aobut the sucessful project implementation	0.43	0.47	0.42	0.47	0.47	0.49
Low returns on innovation	0.41	0.45	0.41	0.46	0.42	0.43
Obstalces linket to the external conditions						
Problems to have external funds	0.32	0.40	0.33	0.39	0.30	0.41
Low cooperation with other firms and organizations	0.30	0.39	0.29	0.39	0.32	0.40
High risk to be copy by other firms or organizations	0.32	0.39	0.32	0.39	0.34	0.38
No institutional capacity to protect the intelectual property	0.28	0.40	0.28	0.40	0.29	0.41
Low offer of services to carry innovation	0.31	0.43	0.31	0.43	0.34	0.46
Panel B: Obstacles to Implementing Innovation in Services	**All Service**		**Traditional**		**KIBS**	
	Innovators	No-innovators	Innovators	No-innovators	Innovators	No-innovators
Obstacles linked to internal capacity and information						
Lack of own resources	0.39	0.48	0.39	0.49	0.36	0.45
Lack of skill workers	0.38	0.40	0.37	0.45	0.38	0.31
Problems to achieve regulation and technical requirements	0.31	0.47	0.31	0.47	0.32	0.43
lack of information about markets	0.33	0.43	0.32	0.45	0.34	0.38
Lack of information about available technology	0.31	0.42	0.33	0.42	0.29	0.40
Lack of information about public policies to support innovation	0.30	0.43	0.28	0.45	0.32	0.40
Obstacles linked to risk						
Uncertainty about demand on goods and services	0.40	0.49	0.40	0.52	0.41	0.43
Uncertainty aobut the sucessful project implementation	0.42	0.48	0.41	0.51	0.43	0.43
Low returns on innovation	0.40	0.43	0.39	0.44	0.41	0.41
Obstalces linket to the external conditions						
Problems to have external funds	0.26	0.30	0.25	0.28	0.27	0.32
Low cooperation with other firms and organizations	0.29	0.33	0.25	0.31	0.34	0.31
High risk to be copy by other firms or organizations	0.29	0.29	0.28	0.25	0.32	0.33
No institutional capacity to protect the intelectual property	0.23	0.25	0.21	0.23	0.25	0.25
Low offer of services to carry innovation	0.27	0.35	0.24	0.34	0.31	0.34

Innovators: Firms that implemented at least one innovation activity. **No-innovators:** potentially innovative firms that do not innovate, but faced at least one obstacle to innovate

9. Conclusions

This study has presented first-hand evidence of the patterns of innovation by firms in the manufacturing and service industries. To the best of our knowledge, this is the first such study of innovation in Colombian service firms. Similarly, the use of EDIT IV data for the manufacturing sector has enabled us to update previously reported findings on innovation patterns. The main results are that Colombian firms do engage in innovation activities regardless of whether they manufacture goods or provide services. More importantly, the study analyzed the link between innovation and productivity using the CDM model. The main results of this exercise are that for manufacturing and service firms, having employees working in R&D and large size are factors that increase the probability that a firm will engage in efforts to innovate. These results are also extensive for firms classified as KIBS or belonging to the medium-high-technological manufacturing sectors. Firms that spend more on innovation also tend to introduce more technological and non-technological innovations, and these results are generalizable to all firms regardless of whether they belong to a more technological sector within manufactures or services. Last, productivity in both service and manufacturing firms increases as firms introduce innovations, with larger effects found in service firms.

Table 16 reports some recommendations for policy making. First, it is important to have more public financial resources made available for innovation. However, it is more important to have better mechanisms to make them available to all firms, especially to micro and SMEs. Clearly, firms that used those funds were more prone to engage more deeply in innovation. Second, the government can help firms protect their innovations by demonstrating the benefits of patents, copyrights, and other intellectual property protections. Chambers of commerce, trade associations, universities, and research centers should carry out joint projects with firms to motivate and engage them in this direction. Third, more financial support or incentives should be given to firms to hire better-trained employees or to train their current workforce to be important assets in the innovation process. Last, R&D has a notable impact on innovation. More direct support by COLCIENCIAS should be provided to firms that engage in innovative activities.

Finally, but not least important, we recommend improving the source of information in two ways. First, representation of services firms in the EDIT for services should be increased because the largest part of the sample is composed of retail firms, education, and health. Second, the representation of small and medium-sized firms in the service sector should be increased in the technological survey. The matching process yielded primarily firms with more than 250 employees, so our main results cannot be extrapolated to small and medium-sized enterprises.

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10. Annexes

Table A1: Description of Variables

Variable	Description	Data Source
Dependent variables at the three stages of the CDM Model		
ID: Decision to Invest	It is a dummy variable taking the value of 1 if innovation expenditure is positive; zero otherwise.	EDIT
IE: Innovation Expenditures	It is the log of innovation expenditures per employee	EDIT
TI: Techonological Innovation	It is a dummy variable taking the value of 1 if there was a new good, service or process as the result from the innovation expenditure	EDIT
NTI: Non-Technological innovation	It is a dummy variable taking the value of 1 if there was a marketing y/or organizational innovation	EDIT
Labor productivity	Added value per employee	
Covariates for the CDM Model		
Exports	It is a dummy variable taking the value of 1 if exports are positive; zero otherwise. It takes	EAM
Foreign ownership	It is a dummy variable taking the value of 1 if there is any foreign ownership.	EAM- EAS
Patent protection	It is a dummy variable taking the value of 1 if the firm obtained a patent as an industrial protection mechanism	EDIT
R&D department	It is a dummy variable taking the value of 1 if the firm has a functioning or employee working in a R&D division within the firm	EDIT
Size	It is the number of the firm's employees at the first year of the biannual period, in natural logarithm.	EDIT
Public funding	it is a dummy variable taking the value of 1 if the firm was granted subsidies or credit from a government institution for innovation activities; zero otherwise.	EDIT
Joint venture innovation	It is a dummy variable taking the value of 1 if the firm undertook cooperation or non-financial joint venture with other firms in order to undertake innovation.	EDIT
Market sources	it is a dummy variable taking the value of 1 if suppliers, clients, competitors, consulting firms and experts were important for new innovation ideas; zero	EDIT
Scientific sources	it is a dummy variable taking the value of 1 if universities, public research centers, and technological institutions were important for new ideas; zero otherwise	EDIT
Public sources	it is a dummy variable taking the value of 1 if newspapers, papers, conferences, Internet were important for new ideas; zero otherwise	EDIT
Investment per employee	The log of capital investment per employee	EAM-EAS
Indicators of Innovation Activities		
Product	the percentage of firms that reported to having introduced at least one product innovation	EDIT
Process	the percentage of firms that reported to having introduced at least one process innovation	EDIT
Innovative Firms	the percentage of firms that reported to having introduced at least either one process or one product innovation	EDIT
New-to-firm	the percentage of firms that reported to having developed innovation new for the firm	EDIT
New-to-market	the percentage of firms that reported to having introduced innovation new for either national or international markets	EDIT
Organization	the percentage of firms that reported having introduced at least one marketing innovation	EDIT
Market	the percentage of firms that reported having introduced at least one organizational innovation	EDIT
Non-tec innovation	the percentage of firms that reported to having introduced at least one marketing innovation or one organizational innovation	EDIT
Any Innovation	the percentage of firms that reported to having introduced at least one Technological of Non-Technological innovation	EDIT
Innovation in all	the percentage of firms that reported to having introduced Technological and Non-technological innovation	EDIT

Table A2: Description of Manufacturing and Service Sectors

The sectoral definitions of high technology and knowledge intensive sectors used here are based on those used by Eurostat and OECD, estimated using the UK's SIC 2007, and are as follows:

Services

CIIU	Description
	KIBS
62	Air transport
41	Water supply and transport
641	Post activities
642	Telecomunications
72	Computer and related activities
6512	Bank activities
921	Entertainement: cine, radio, tv
	Less KIBS
50	Wholesale automotriz
51	Wholesale trade
52	Retail trade
40	Utilities (energy, gas, hot water)
551	Hotels
90	Cleaning
552	Restaurants
602	Land transport (apssengers)
604	Land transport (cargo)

Manufacturing

CIIU	Description
	High Tech
24	Fabricación de sustancias y productos químicos
29	Fabricación de maquinaria y equipo n.c.p.
31	Fabricación de maquinaria de oficina, contabilidad e informática
32	Fabricación de equipo y aparatos de radio, televisión y comunicaciones
34	Fabricación de vehículos automotores, remolques y semirremolques
35	Fabricación de otros tipos de equipo de transporte
33	Fabricación de instrumentos médicos, ópticos y de precisión y fabricación de relojes
	Low Tech
15	Elaboración de productos alimenticios y de bebidas
16	Elaboración de productos de tabaco
17	Fabricación de productos textiles
18	Fabricación de prendas de vestir; adobo y teñido de pieles
19	Curtido y adobo de cueros; fabricación de maletas, bolsos de mano, artículos de talabartería y
20	Producción de madera y fabricación de productos de madera y corcho, excepto muebles; fabricación de
21	Fabricación de papel y de productos de papel
22	Actividades de edición e impresión y de reproducción de grabaciones
36	Fabricación de muebles; industrias manufactureras n.c.p
23	Fabricación de coque, productos de la refinación del petróleo y combustible nuclear
25	Fabricación de productos de caucho y plástico
26	Fabricación de otros productos minerales no metálicos
27	Fabricación de metales comunes
28	Fabricación de productos elaborados de metal, excepto maquinaria y equipo

Table A3. Stage 1: Probability of Investing in R&D and Intensity of R&D Expenditure per Employee

	Manufacturing						Services					
	All		Low-tech		High-tech		All		KIBS		Less KIBS	
	log(R&D/emp)	R&D_dummy	log(R&D/emp)	R&D_dummy	log(R&D/emp)	R&D_dummy	log(R&D/emp)	R&D_dummy	log(R&D/emp)	R&D_dummy	log(R&D/emp)	R&D_dummy
	1	2	3	4	5	6	1	2	3	4	5	6
Exporting	0.445**	0.0542	0.418*	0.00353	0.366	0.136						
	(0.173)	(0.0523)	(0.216)	(0.0622)	(0.296)	(0.0998)						
Foreign ownership	0.922***	-0.135*	0.752**	,-0.122	1.257***	-0.232*	1.344***	0.349*	1.042***	0.454**	1.301	0
	(0.220)	(0.0749)	(0.304)	(0.0940)	(0.359)	(0.132)	(0.313)	(0.203)	(0.347)	(0.217)	(1.290)	(0)
Patent protection	-0.804***	0.658***	.-0-290	0.584***	-1.715***	0.758***	0.243	0	-1.021	0		
	(0.285)	(0.124)	(0.375)	(0.156)	(0.481)	(0.219)	(0.807)	(0)	(1.012)	(0)		
Public financial support	0.421		0.291		0.550		1.876***		1.838***		1.713	
	(0.322)		(0.377)		(0.719)		(0.513)		(0.684)		(2.912)	
Cooperation in Innovation activities	0.173		0.211		0.129		0.525***		0.422*		0.363	
	(0.149)		(0.181)		(0.288)		(0.184)		(0.227)		(0.378)	
Market source of information	-0.157		.-0.0986		-0.269		0.317		0.0434		0.609	
	(0.218)		(0.266)		(0.372)		(0.228)		(0.313)		(0.467)	
Scientific sources of information	-0.0128		0.0141		-0.150		0.298		0.591**		-0.543	
	(0.168)		(0.208)		(0.275)		(0.212)		(0.265)		(0.437)	
Public source of information	0.0977		.-0.0338		0.464		0.364		0.217		0.654	
	(0.207)		(0.248)		(0.370)		(0.231)		(0.283)		(0.444)	
Research and development		0.888***		0.849***		0.790***		0.253*		0.244***		0.459***
		(0.0523)		(0.0650)		(0.0912)		(0.152)		(0.0485)		(0.101)
Size		0.219***		0.227***		0.244***		0.299***		0.312		0.158
		(0.0174)		(0.0205)		(0.0359)		(0.0414)		(0.221)		(0.436)
Constant	12.98***	-2.311***	13.05***	,-2,372***	13.17***	-2.240***	11.86***	-0.361*	12.61***	-0.239	10.98***	-0.759*
	(0.315)	(0.0672)	(0.395)	(0.0794)	(0.501)	(0.132)	(0.167)	(0.199)	(0.269)	(0.252)	(0.306)	(0.399)
Observations	7,203	7,203	5.761	5.761	1,442	1,442	684	684	352	352	210	210

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

Table A4. Stage 2 Innovation Outcomes. Joint Probability of Investing in TI and NTI

	Manufacturing			Services		
	All	**Low tech**	**High tech**	**All**	**KIBS**	**Less KIBS**
	TI	TI	TI	TI	TI	TI
RD_p (predicted R&D expenditure per employee)	**0.036***	**0.077****	**0.0315**	**0,293*****	**0.1533*****	**-0.084****
	(0.170)	**-0.0258**	**(0.0235)**	**(0.036)**	**(0.0394)**	**0.042**
Exporting	0.011	-0.011	0.0202			
	(0.0103)	(0.0112)	(00.0214)			
Foreign Ownership	-0.0380	-0,046***	-0.0733**	-0.371***	-0.144**	0.391
	(0.0113)	-0.008	(0.0255)	(0.0533)	(0.088)	(0.209)
Size	0.037***	0,0331**	0.061***	0.026**	0.0308	0.028
	(0.0023)	(0.0026)	(0.0076)	(0.0136)	(0.0179)	(0.0295)
Observations	7203	5761	1442	684	352	210

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

Table A5. Stage 3: Impact of Innovation on Labor Productivity

	Manufacturing				Services			
TI_p (Predicted of Technological innovation)	**1.220*** **			**1.132*** **	**0.420*** **			**0.419*** **
	(0.226)			**(0.226)**	**(0.111)**			**(0.113)**
NTI_p (Predicted of Non-Technological innovation)		**1.329*** **				0.786***		
		(0.133)				(0.203)		
RD_p (predicted R&D expenditure per employee)			0.619***				0.440***	
			(0.0334)				(0.0920)	
Investment per employee	5.25e-06***	5.21e-06***	4.84e-06***	5.20e-06***	3.00e-08	2.98e-08	2.62e-08	2.99e-08
	(3.66e-07)	(3.64e-07)	(3.59e-07)	(3.65e-07)	(2.39e-08)	(2.39e-08)	(2.37e-08)	(2.39e-08)
Size	-0.235***	-0.193***	0.0880***	-0.218***	-0.103**	-0.0989**	-0.0765*	-0.103**
	(0.0762)	(0.0378)	(0.0101)	(0.0760)	(0.0489)	(0.0484)	(0.0454)	(0.0490)
Non Technological innovation				0.258***				0.00911
				(0.0398)				(0.126)
Observations	7,203	7,203	7,203	7,203	684	684	684	684

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

Annex 2

Survey to Policymakers about Existing Policies to Promote Innovation in the Service Sector

Following the guidelines outlined by the IDB research head group on collecting information regarding the existing state of innovation policy in the service sector, the Universidad del Rosario research team sent questionnaires to different policymakers in the Departamento Administrative de Ciencia, Tecnología e Innovación (COLCIENCIAS), Departamento Nacional de Planeación (DNP) and the Observatiorio de Ciencia y Tecnología—all of them government-affiliated or public institutions. Interviews were also conducted with some of them. The remainder of this section summarizes the interviews with the officials affiliated with COLCIENCIAS. These interviews describe existing policies and the lack of policies and the need for policies and tools in certain areas.

A. National Policy Background

Strategies and National Innovation System

The officials agree a formal innovation policy for the service sector is lacking. However, there are implicit policies and agreements in specific areas and industries, which are the result of procedures implemented by Sistema Nacional de Ciencia y Tecnología, establishing a link with the service sector.

Probably the main underlying factor for the absence of policy in this area is the lack of a proper definition for innovation in services. Colombia only recently began building an agenda following the international debate from global institutions, such as the OECD, ECLAC, the IDB, and RICIT.

The officials interviewed were enthusiastic about the innovation in services and the assessment of the existing policies (if any). Once innovation in services is defined as innovation in the tertiary sector, there is consensus on the fact that explicit policies are either poor or entirely lacking. Furthermore, the experts propose redefining the concept of innovation in services. A new definition would include innovation along the productive chain, and not attached to the service sector only. Under this setting it is not difficult to find several policies related to innovation in services, such policies are part of a continuous process of the existing policy tools to foster research and development. Under this broader definition of innovation in services, it is much easier to exploit technical change or what the experts call knowledge management.

Besides the difficulties with a definition, the only existing source of information available to obtain a picture of the state of the art is the innovation survey EDIT. EDIT is the best source of information for understanding innovation in the service sector. However, many conceptual definitions and innovation measures are not included in EDIT, such as innovation in services as business model, customer experience, the use of ICT in innovation. The absence of a metric to measure these aspects of services is a major shortcoming.

Although there is currently innovation policy in services or a short- or long-term planning process, there is a basic understanding of innovation, and incipient efforts are observable. Funding initiatives for R&D in ICT, education, and health are observed. There is no long-term view of R&D+I. There is no study identifying different innovation scenarios, nor is there a focal point toward which such policies should aim. The Sistema Nacional de Ciencia y Tecnología is still using a traditional approach to 12 knowledge groups and lacks the multidisciplinary approach of research between innovation and knowledge.

Policies by Sectors

Despite the importance of the service sector to the Colombian economy and its willingness to adopt innovation and be a key player in productivity growth, there is no policy to foster innovation.

There are, however, industry-specific guidelines in private, public, and state-related activities. An example is the innovation policy from the ICT ministry. This ministry has fostered and implemented the use of telecommunications in government services. The President’s council for good governance practices has fostered an organizational change. Both entities have proposed a set of explicit innovation policies within the State, which have had effects across the board, such as the “Gobierno en Línea” initiative. The partially state-owned oil enterprise, ECOPETROL, has implemented several organizational changes. And the partially state-owned bank BANCOLDEX (a second-tier bank to promote foreign trade) has also fostered innovation policies via the INNPULSA program.

COLCIENCIAS, has implemented innovation policies in specific service industries, such as the “Programa nacional de innovación e investigación en TICS” which is a joint effort with the ICT ministry to Foster ICT innovation research. Specific tools within this policy are financial leverage and entrepreneurial training.

Stakeholders

In 2011, the Colombian government merged the national competitiveness system with the national innovation system, under Act 286. However, the regulation is still pending and the definition of tasks depends on the Competitiveness Council (a public-private board in charge of outlining national priorities in this area).

COLCIENCIAS is an active member of the national competitiveness system and member of the executive committee. Among its duties are to coordinate policies and the strategic planning of the science, innovation and competitiveness organization. This implies the need to define: i) the active entities, such as COLCIENCIAS and BANCOLDEX (via the INNPULSA program); and ii) promote the science and technology system at the regional level. A further objective is to link these initiatives with the national royalty distribution system. The biggest challenge is to have a clear separation of entities into knowledge management and funding sources. However, there are stakeholders such as: COLCIENCIAS, which is associated with the national innovation program in ICT, where some other policies are proposed.

The lack of policies, tools, and stakeholders in innovation in services is closely associated with the definition of innovation. Colombia, as well as many other Latin American countries, does not have a clear definition of innovation in services. An underlying concept is that innovation in services is associated with the business model, which is far from the definition of R&D. This is why innovation is scarce and innovation in ICT is notable, although innovation can be found in the indicators of the most active industries in the EDIT survey.

B. National Policy Background

Promoting Policies

1. Please identify and describe policies and measures aimed at fostering innovation in the service industry that work to promoting the supply of innovation in services.

- There are policies fitted to specific cases, such as taxing subsidies; however they exclude innovation in services and support to R&D.

2. Please identify and describe policies and measures aimed at fostering innovation not related to the industry.

- There are policies that apply across the board, such as the e-tics.

3. Please describe the policies and efforts aimed at promoting innovation in services through the demand for specialized services.

- Fostering private demand through non-tax income from innovation in software with high local (Colombian) R&D.

4. Please describe the policies and measures aimed at creating a favorable framework of innovation in services.

- The ICT and networks promoted by the ICT ministry.

C. Policy Measures

5. Please describe the most important policies and measures aimed at fostering innovation in services, seeking new actors in innovation, new activities in innovation, and new innovative business solutions.

- Value added in networks through R&D+I in the call for joint funding between firms and universities.
- New business models through support to entrepreneurship of technologically based ICT. The joint support of COLCIENCIAS and INNPULSA.

6. Please talk about the most important policies and measures aimed at promoting the capabilities associated with innovation in services.

- Research, education, basic training, and learning through calls for funding.

- Multidisciplinary skills and capabilities, such as the support to Artica (Medellín). Artica is a high quality center in ICT with a multidisciplinary focus. The same for the Centro de Bioinformática in Manizalez.

7. Please discuss the most important policies and measures undertaken in your country aimed at developing markets and infrastructure to foster innovation in services.

- A favorable regulatory framework, using tax incentives to promote innovation in software.
- Smart standardization to foster smart networks in electric energy industry.
- Smart financial solutions to foster growth in software industries.

D. Future Development and Policy Needs for Innovation in Services

It is very important to have a Latin American definition of innovation in services, which will allow countries to Create appropriate measures and indictors and implement the approach of international organizations such as the OECD, RICIT, and ECLAC.

Colombia must complete its innovation strategy to outline specific goals towards innovation in services. Currently innovation in services is only related to innovation in ICT.

Finally, the current royalty and taxation system must be properly implemented so that it is linked to innovation in services. There is an interesting opportunity in the current availability of funding from the royalty law to foster innovation in regionally diverse areas. This would allow an evaluation toward innovation in services, especially knowledge-based sectors.