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Marcela Umaña-Aponte
Fernando Estupiñan
Cristian Duque

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Innovation and Productivity in Services: An impact evaluation of Colciencias funding programs in Colombia*

Marcela Umaña-Aponte
marcelaua@gmail.com

Fernando Estupiñan
festupinan@metrica.com.co

Cristian Duque

METRICA
Investigaciones y Proyectos Sociedad por Acciones Simplificada,
Calle 22 BIS Nº 48-65 Of. 806 Bogotá, Colombia

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Contenidos

Abstract

Globalization and the transition of economies and societies towards a system based on knowledge and information have intensified competition and interdependence among countries. We present an impact evaluation of funding programs, designed to promote innovation activities in the Colombian service sector. The incorporation of two novel panel data at firm level allows to control for unobserved heterogeneity. Results indicate that there may be a significant impact in terms of labour productivity for small companies and KIBS and of gross margins for large companies. This is especially true for projects of short (one year or less) duration.

Keywords: Service Sector, Impact Evaluation, Innovation Policy.
JEL Classification: C31, H32, H59, O38.

1. Introducción

Today, firms face strong competition due to increased globalisation. This tendency has encouraged the development of new business structures and strategies in which technological innovation is essential for growth.

Economic research has developed theoretical and empirical models that show evidence that innovation increases productivity and boosts economic growth.

The service sector is, today, the main contributor to national production and economic growth of most countries in the world. The analysis of how innovation is developed and applied in this sector is crucial for economies and governments.

Certain market conditions make innovation investments in the service sector less attractive than in others. These conditions include credit restrictions, asymmetric information, incomplete appropriability, uncertainty and coordination failures that impede the creation of positive network externalities. Although these conditions are faced by the economy as a whole, they are exacerbated by the rapid diffusion of knowledge and the fact that innovation outcomes are, in general, of intangible nature in the service sector. For these reasons, public policies that aim to promote innovation are of particular relevance for services. The main contribution of this study is a thorough evaluation of the impact on firm productivity of public funding programs for innovation projects in the Colombian Service Sector. Literature on the relationship innovation–productivity in Colombia is scarce.

We use two novel panel dataset at the firm level that are combined to estimate fixed effects (FE) models. FE allows us to control for unobserved heterogeneity across firms and correct the endogeneity that arises from self–selection and omitted information. Estimates will provide evidence on the causal relationship between funding granted by Colciencias and measures of labour and capital productivity, income and profits of companies.

Results indicate that Colciencias' funding programs might have a large-positive impact on labour productivity (24.2%), sales revenue and gross margins in the service sector. In particular, Knowledge Intensive Business Services (KIBS) show the largest gain with increases in their labour productivity of 25.7%. Small companies also experience increases in their labour productivity (23.1%). The adoption of short innovation projects (implemented in one year or less) generates increments of up to 62.4% in labour productivity. This effect is evident on the second year after the funding was granted. The implementation of long projects (more than one year) show positive effects only for KIBS with increases in labour productivity of 17.8%. The main beneficiaries in terms of gross margins are large companies with increments of 8.1%.

The following section presents the motivation and relevant literature that has documented the relevance of innovation on firms and economies. Section three describes the Colciencias funding programs for innovation projects that are the subject of this impact evaluation. Details of the data used in empirical estimations are presented in section four. The methodology and results are described in section five and six, and section seven highlights the main findings of the study.

2. Background

Globalization and the transition of economies and societies towards a system based on knowledge and information have intensified competition and interdependence among countries. This tendency has encouraged the development of new business structures and strategies in which technological innovation is essential for growth.

Technological innovation is defined as the incorporation of knowledge into the production process that increases productivity and efficiency through the use of new and improved inputs or processes that, in turn, produce new or improved products. Internationally, innovation is defined as "the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations. ... An innovation can be more narrowly categorised as the implementation of one or more types of innovations, for instance product and process innovations." (OECD; 2005).

The economic literature has provided evidence that innovation is fundamental to increase productivity and to create competitive advantages (Dosi et al.; 1990; Padoan; 1997; Griffith et al.; 2006; Mairesse and Mohnen; 2010), which yield higher firm profits and rapid economic growth for countries (Fagerberg et al.; 2010).

According to Pérez (1986) two important dimensions of technological innovation are: a techno-scientific one in which knowledge is integrated into the production process; and an economic one in which new products, created by innovation, reach the market and might be a business success, depending on the degree of apropriability and the diffusion strategy (Pérez; 1986). When those new products become an economic phenomenon through the market, the impact of innovation on productivity is materialised. Therefore, research and development (R&D) activities are crucial for firms through the modification of production processes and the increase on the efficient use of factors and inputs (Dosi et al.; 1990, p. 177). R&D produces new ideas that are adapted and applied to new technologies that, in turn, create new products and services (IADB; 2010).

At the macroeconomic level, innovation has become the mechanism to achieve a stable growth path and to generate high levels of value added (Griliches; 1998). This phenomenon has motivated governments to design public policies that encourage R&D and innovation activities within firms (Hall and Maffioli; 2008), and although these policies and their implementation are very recent, their impact has been the centre of interest and debate among economists during decades (starting from Schumpeter; 1934).

The economic theory has developed several models that attempt to explain the determinants of economic growth and productivity. Their origins are the economic growth models developed by Solow (1956) and Cass (1965); Koopmans (1963); Ramsey (1928). However, these models strongly simplify the production system and are not able to explain the innovation process of firms, since technological process are taken as exogenous. Similarly, the subsequent AK model developed by Frankel (1962) failed to differentiate capital accumulation from technological progress.

The product-variety model (Romer; 1990) and the quality-ladder growth model (Aghion and Howitt; 1990) distinguish final goods from inputs (intermediate goods). The latter implements the concept of endogenous growth in which innovation developments increase productivity and improve the quality of goods and services. It also incorporates previous innovations into the production process as a determinant of technological progress, and thus, of economic growth. These results are consistent with the definition of technological innovation of the Oslo Manual discussed above (OECD; 2005).

In the last two decades, applied literature has developed and estimated empirical models that analyse the relationship between innovation and productivity. The foundation of many of these studies is the classic economic growth theory (Solow; 1956) and the product-variety model (Romer; 1990). These studies consider extensions of the theoretical-base model in which the creation of new varieties of products and services are not only the result of the interaction among complementary sectors (intermediate consumption), but also of their final consumption (Grossman and Helpman; 1993; Gancia and Zilibotti; 2005).

Other studies base their empirical analyses on the Schumpeterian growth model (Segerstrom et al.; 1990; Corriveau; 1994). One of the most influential is the CDM model developed by Crepon et al.

(1998). This model evaluates the impact of technical research on innovation and the impact of innovation on productivity. Other relevant studies have compared economic growth trends and innovation on the basis of both theoretical models: the Schumpeterian model of endogenous growth and a semi-endogenous growth model (Ha and Howitt; 2007; Kortum; 1998; Segerstrom; 1998; Jones; 1995). The difference between those two approaches (endogenous and a semi-endogenous) is that inputs related to research and development (R&D) are added into the endogenous model. Specifically, the inclusion of the proportion of employees working in R&D activities in the firm and the expenditures on R&D in the United States (US) economy.

Using statistical methods (cointegration and out-of-sample predictions), Ha and Howitt (2007) show that productivity growth in the US is stationary in the long run while R&D resources tend to decrease, and conclude that these two variables are not cointegrated. They also find that the returns to scale of knowledge are constant, implying that productivity growth does not depend on technological progress in the long run.

Other empirical studies have addressed the innovation-productivity relationship from different perspectives. A comparison of the relationship between generation of intellectual property (patents) and innovative capacity in 17 OECD countries shows that, apart from traditional factors (labour and capital), public policy measures are key factors that explain the production of international patents (Furman et al.; 2002). Separately, a panel of 752 British companies show that knowledge flows within industries (from competitors and suppliers), and in less extent from customers and academic research, explain almost 50% of the total factor productivity (TFP) growth of firms (Crespi et al.; 2008). These findings are based on the theoretical model of endogenous growth developed by Griliches (1979).

Two main patterns of innovation have been identified by the literature (Breschi et al.; 2000). The first one is a "creative destruction pattern where innovations are introduced by firms that did not innovate before" (widening). The second one is a "creative accumulation pattern where innovations are introduced by firms that innovated before" (deepening). Education progress is vital to promote basic and applied research that promote both innovation patterns and, in turn, create competitive advantages. National innovation systems (or technological regimes) highly influence both patterns of innovation. However, protection of intellectual property, appropriability conditions and knowledge accumulation are more relevant for the deepening pattern.

In conclusion, the relationship between innovation and productivity at both micro and macro levels have been widely documented by the theoretical and empirical literature. They provide evidence that technological innovation is a determinant factor of productivity and growth, and that public policies that encourage innovation are key to promote the generation of intellectual property and thus, innovative practices.

Innovation and productivity in the region

The application of the CDM model has helped to analyse the innovation–productivity relationship in six Latin American countries (Crespi and Zuñiga; 2012). Results show that this relationship is positive for all countries (Argentina, Chile, Colombia, Costa Rica, Panamá and Uruguay) and of higher magnitude than for industrialised countries. However, the calculated semi-elasticities are very different among countries, being much lower in Argentina than in Colombia, for example.

Literature on innovation in Colombia is scarce. The available literature mainly focuses on explaining the determinants of firm innovation, but not the relationship between innovation and productivity. The only study that analyses this relationship is Crespi and Zuñiga (2012).

In Colombia, the size of the firm is positively correlated to the decision of investing in innovation activities but negatively correlated to intensity of investment (Alvarado; 2000). This conclusion implies that large firms have intrinsic advantages that facilitate their investment in R&D but the relative amount of investment is smaller compared to small firms. Small firms tend to invest more as

they seek to improve their market position and increase their productivity[1]. In addition, firms with foreign investment (foreign capital share) or with access to international markets tend to invest more in R&D activities.

In the manufacturing sector, investments in innovation activities are also highly related to size, foreign investment and human capital (Langebaek and Vásquez; 2007).

Innovation in the Service Sector

The service sector is today the most important contributor to income generation for most economies. In OECD countries, this sector represents 70% of the GDP and generates 80% of their economic growth (Uppenberg and Strauss; 2010). In Colombia, it represents 63%–64% of the GDP and generates 61.7% of the total employment in the country (DANE; 2009). Globalization and new information and telecommunication technologies (ICT) have boosted the growth of the service sector around the world. Factors such as the need of international transactions, the systematisation of processes and the use of ICT have accelerated its dynamism (Maurer and Tschang; 2012). The quick flow of knowledge and innovation in the service sector has allowed small firms to have access to knowledge that was impossible to attain before (Kox and Rubalcaba; 2007). In Estonia, the positive effect of innovation on productivity is stronger for less knowledge intensive firms in the service sector (Vahter and Masso; 2011). New available technologies have allowed firms to reduce costs of production and risks of business transactions. They are also relevant for employment and income generation at macro level. All these factors justify deep research and understanding of the innovation process in the service sector.

According to Maurer and Tschang (2012), competitiveness of firms is increasingly determined by their operation across regions and multiple networked value chains, where outsourcing and offshoring help to explain the importance of services in modern economies. In particular, KIBS are key to innovation, not only in services, but also in manufacturing, and for its contribution to aggregate productivity growth (Uppenberg and Strauss; 2010). Even the role of services sector in allowing small firms to have access to knowledge, that was impossible to attain before, is recognized (Kox and Rubalcaba; 2007).

In Estonia, the positive effect of innovation on productivity is stronger for less knowledge intensive firms in the service sector (Vahter and Masso; 2011). New available technologies have allowed firms to reduce costs of production and risks of business transactions. They are also relevant for employment and income generation at macro level. All these factors justify deep research and understanding of the innovation process in the service sector.

Although the relevance of services is generally accepted, there is a debate over the nature of innovation in services sector. While initially it was suggested that services adopt innovation from other sectors (Cohen and Zysman; 1987), recent work has been devoted to show that the dynamics of innovation is not so different from manufacturing. According to Gallouj and Savona (2009), measurement biases are responsible of the underestimations of innovations and economic performances. This is because; service output is not embodied in anything that is physically quantifiable. It is a process, a sequence of operations, a formula, a protocol, a problem solution.

This definition is also important because of the transformation of some companies from manufacturing to service providers. This shift has been accompanied by a shift towards subscription pricing instead of a single payment for a piece of manufactured equipment. This is referred as the *servitisation of products* (Uppenberg and Strauss; 2010).

[1] This result is analogous to Crespi and Zuñiga (2012) who find that intensity of investment is higher in developing countries than in developed countries.

Although innovation, in services sectors, has specific features such as the interaction required between client and provider or the greater importance of human and organisational factors (Rubalcaba; 2006), it should be emphasized that market failures and systemic failures affecting innovation in services are similar to those that occur in the manufacturing sector (Cruysen and Hollanders; 2008). The existence of these failures suggests that there is under-investment in services innovation that justifies policy intervention.

Role of public policy in promoting innovation

Certain market conditions slow down investment in innovation. These conditions, called "market failures", limit the access to credit due to asymmetric information, make the complete appropriability of innovation rents difficult, create uncertainty and generate coordination failures that impede the creation of positive network externalities (Aghion et al.; 2009).

In the service sector these market failures are exacerbated, mainly because the results of innovation investments are normally intangible assets. This increases uncertainty and makes appropriability of outcomes even more difficult. As pointed out by Rubalcaba et al. (2010), there are also system failures that prevent firms from engaging in innovation activities.

Governments design policy programs that aim to counteract these market failures. These programs need to be evaluated to assess their effectiveness in terms of the expected results.

Previous evaluations, made by IADB between 2005 and 2007, show that government Technology Development Funds (TDF) in Argentina, Brazil, Chile and Panama do not crowd out private investment and that they positively affect R&D intensity. The evidence, also suggests that participation in TDF encourages firms to engage in innovation activities (Hall and Maffioli; 2008).

A most direct approach to the Colombian case made by Crespi et al. (2011), using data sets for 13 years from the manufacturing survey, found that participation in Colciencias programs increases labour productivity by 16% and product diversification.

In contrast with previous evaluations, we will focus on evaluating Colciencias programs that promote innovation activities in services firms due to its relevance for the Colombian economy. The following section describes the available programs for innovation promotion designed by Colciencias.

3. Colciencias funding programs

Under the Colombian program of Science, Technology and Innovation, Colciencias provide support to research projects in eleven areas of knowledge including health, education, biotechnology, industrial and IT technology development and social sciences. For each area, there is a committee (or National Council) in charge of defining general guidelines, evaluate project proposals and select the successful projects.

Colciencias have four funding programs: (i) Contingent funding: for projects without immediate financial benefit. This funding is normally granted to projects headed by non-for-profit institutions, however private companies can be part of such projects as beneficiaries. This program represents 21% of the granted benefits in our sample. (ii) Credit line: for innovation projects with outcomes that are fully appropriable by the company (17% of the sample) (iii) Co-funding (cofinanciación): for cooperative projects that involve beneficiary entities (companies) and implementing agencies (research centres/universities, etc.) (57%); (iv) Mixed: any combination of all of the above (5%).

None of the programs provide full funding to projects. Therefore, companies must demonstrate that they have enough resources for the full implementation of the project. These complementary funds

should be certified and signed by the legal representative of the company. Colciencias does not fund expenditures such as insurance, maintenance, purchase of used equipment or furniture or labour costs. Complementary resources should fund this type of expenses. Applicants must demonstrate that they have those complementary resources.

All proposals must be described in detail with all activities that will generate, adapt or apply new knowledge. They must also contain a clear project schedule and a clear budget, which must state the exact duration of the program and all resources that will be invested in their development and implementation.

Local and foreign peer–reviewers evaluate project proposals in a confidential process and provide technical recommendations on its quality, pertinence and financial and technical viability. Based on these recommendations the National Council meets and approve (or reject) the funding for the research project. The Council normally include the Director of Colciencias (or their representative), private sector experts, researchers and representatives of the National Planning Department (DNP) and/or relevant Ministries.

4. Data

The empirical model is estimated using two sources of information that contain micro-data at the firm level. The first one is a panel data provided by Colciencias with all institutions that applied for innovation projects funding between 1999 and 2010. The data set contains information on the type of funding, the length of the proposed project and the amount granted. In case that the project was not approved, the amount granted is zero, and therefore the institution did not receive the benefit (not treated). There are 20,773 observations in this data set that correspond to 3,177 applicant institutions during the 12 years.

Since this impact evaluation focuses on the service sector only, we want to exclude all companies from other sectors and other institutions that applied to Colciencias' funding. First, we remove all non-for-profit organisations such as universities, research centres, NGOs, foundations and governmental and international institutions. We exclude them on the basis that any public funding for innovation projects will not affect their own productivity but the productivity of third parties. We are left with 2,411 innovation projects to 1,739 companies[2] from all economic sectors. 933 of those projects were approved and 1,478 were rejected between 1999 and 2010.

The second dataset is a panel from the National Service Sector Survey (NSS) conducted by the National Department of Statistics (DANE) between 2006 and 2010. This is a restricted database that contains information on the ISIC[3] (top level only), employment (temporal and permanent), income, costs, depreciation, assets and capital expenditure for each company, each year. The sub-sectors included in the sample are detailed in Table 1.

[2] 562 were granted the funding. 971 did not get the funding and for the rest 206 some projects were approved and some rejected.
[3] International Standard Industrial Classification or CIIU in Spanish.

Table 1 Service Activities Included in the NSS from 2006 onwards

ISIC Top Level	No	Description
H	55	Hotels and Restaurants
I	63	Supporting and auxiliary transport activities; activities of travel agencies
I	64	Post and telecommunications
K	70	Real estate activities
K	71	Renting of machinery and equipment without operator and of personal and household goods
K	72	Computer and related activities
K	74	Other business activities
M	8050	Private Higher Education
N	851	Human health activities
O	921	Motion picture, radio, television and other entertainment activities
P	93	Other service activities

Both datasets are merged using the NIT (Business Tax Number), which uniquely identifies each registered business in Colombia[4].

The micro-data from Colciencias allow us to clearly identify the treatment and control groups as it includes all companies that applied to funding programs, even if they were not granted. The final dataset contains 475 observations. Table 2 details the number of companies in the treat and control group for each year.

Table 2 Number of companies in the treated and control group by year

	Number of Companies	
Year	Treated	Control
2006	18	77
2007	24	71
2008	32	63
2009	41	54
2010	47	48
Total observations	***162***	***313***

Dependent Variable

We select measures of productivity and performance to evaluate the impact of innovation programs in the service sector in Colombia. This is consistent with previous studies that use sales and profit margins as dependent variables in impact evaluation (Crespi and Zuñiga; 2012; Cainelli et al.; 2006). The selected variables are:

- Labour productivity (ln): measured as the ratio sales–number of employees. This variable is commonly used as a proxy of TFP, because R&D investments improve products or processes that increase the firm's income without changes in the use of inputs or factors. Therefore, companies can compete with differentiated products and improve their market position and share.

[4] This process was made by DANE directly because we cannot have access to the identification numbers due to confidentiality issues. We asked DANE to include all companies in the NSS even if they are not present in the Colciencias database.

- Marginal productivity of capital (ln): sales to capital ratio, used as a proxy of productivity in the literature (Love and Zicchino; 2006). Capital is calculated as the difference of property plant and equipment minus capital expenditure (PPE - CAPEX) for each year.
- We will also evaluate effects on sales (ln), gross profits (ln)[5] and gross margin. Gross Margin is the gross profit to sales ratio[6] and is a measure of efficiency and sales profitability. It also represents what portion of sales revenue is available to cover the other costs of running the business.

Descriptive statistics of these variables as well as other relevant indicators are presented in Table 3.

Table 3 Descriptive statistics

Variable	Description	Obs	Mean	Std. Dev.	Min	Max
empleo	No. of employees	385	339.95	741.00	1.00	5,303.00
capex	Capital Expenditure*	385	6.54	42.10	0.00	588.00
ppet	Property, Plant and Equipment*	385	59.80	279.00	-0.98	2,600.00
lnppe	ln(ppet)	378	14.35	2.38	8.83	21.68
prodlab	Labour productivity	385	126,168	241,273	5,910	3,634,257
lnprdlab	ln(Labour productivity)	385	11.32	0.79	8.68	15.11
kprod	Marginal productivity of Capital	378	25.96	114.43	0.00	1,813.85
lnkprod	ln(Marginal productivity of Capital)	378	1.65	1.60	-5.75	7.50
invcap	Investment to capital ratio	379	0.24	0.74	-7.29	6.28
insertot	Sales*	385	41.80	139.00	0.02	1,550.00
lnrev	ln(sales)	385	15.98	1.63	9.78	21.16
utb	Gross profits*	385	20.10	87.00	-21.10	1,050.00
lnutb	ln(Gross profits)	372	15.08	1.60	10.36	20.78
gm	Gross margin	385	0.43	0.25	-1.51	0.96

** In million Colombian Pesos (COP)*

5. Model Specification and Results

5.1 Methodology

We will initially analyse the relationship between productivity and innovation programs by estimating a linear simple model (OLS[7]). Point estimates will reflect the average effect of the innovation policy on our dependent variable. They provide a simple correlation of the analysed variables as under this model the conditional independence assumption is rarely met. Therefore, it is very likely that the estimated parameters are biased. The OLS model is:

$$y_{it} = \alpha + \beta\ Colciencias_{it} + \lambda_t + \varepsilon_{it} \qquad (1)$$

in which, y_{it} is the measure of productivity or performance of the firm *i* in year *t*. *Colciencias* is a categorical variable that indicates whether Colciencias approved the project and the firm received the financial benefit. Given that the implementation of the project can last more than one year, it is possible that the effects of the program are not immediately observable. Therefore, *Colciencias* take value of 1 from the year of treatment until the end of the period. The λ_t term indicates year fixed effect variables that control for unobservable time factors at which all companies might have been exposed.

[5] Only 4% of companies in the sample reported negative gross profits (Table 3).
[6] *Grossmargin = grossprofit/sales*
[7] or, Ordinary Least Squares

The potential bias on the estimated parameters can arise from the omission of relevant information that it is not observable or is not available for the researcher. This is called *omitted variable bias*. In addition, potential endogeneity might arise due to a self-selection process in which companies, due to unobservable characteristics or asymmetric information, decide to participate or not participate in the program. This also might be due to eligibility conditions that might prevent companies from participation. Therefore, the treatment group is not a random sample of the population.

A further step of selection might arise if the selection process of Colciencias is not random. We believe this is very unlikely, as none of the observable characteristics of companies are relevant for the selection decision. The criteria for approval or rejection are only related to the quality, feasibility and innovation degree of the project. Experts determine whether the project actually generate innovative knowledge, whether it is a novel area of research for the company, whether the research project is well formulated and of feasible application, and whether it employs adequate human capital. The projects receive a score and a rank position according to their pertinence and viability. A final committee make the final approval decision, but normally those with higher scores are the ones approved. Financial indicators or particular characteristics of the companies (size, etc) are not taken into account and they are not part of the application requirement and should not be included in the final proposal.

Potential endogeneity can be addressed by controlling for unobserved characteristics of companies. Since we are working with longitudinal datasets, we can estimate a fixed effects model[8] that allows us to make those controls as follows:

$$y_{it} = \alpha + \beta\ Colciencias_{it} + \eta_i + \lambda_t + \varepsilon_{it} \qquad (2)$$

The new term in the model η_i represent fixed effect at the firm level and controls for unobservable characteristics of companies. All other components of the model are the same as in OLS, Equation (1).

As mentioned above, the effects of the program may take time to materialize, depending on the nature and duration of the project. Therefore we estimate three additional models in which we evaluate heterogeneous effects of time into treatment (3), duration of the project (4) and the interaction of them both (5).

$$y_{it} = \alpha + \sum_{j=0}^{5} \beta_j\ D_{it}^{j} + \eta_i + \lambda_t + \varepsilon_{it} \qquad (3)$$

In this model, we add five categorical variables D^j_{it} it that indicate the number of years into treatment. These variables take value of 1 for all years after the benefit was granted in the period 2006 - 2010 (see descriptives in Table 4).

The impact of the financial programs might also vary depending on the duration of the project. Short projects, for example, might produce productivity improvements of less magnitude that longer projects. Therefore, it is relevant to analyse those variations. In order to assess those differences, we estimate a new model with two categorical variables D_k that indicate whether the approved project was shorter than one year (inclusive) or longer than one year (Table 4), as follows,

$$y_{it} = \alpha + \sum_{k=0}^{2} \beta_j\ D^k + \eta_i + \lambda_t + \varepsilon_{it} \qquad (4)$$

Finally, we would like to evaluate the heterogeneous effects of the Colciencias funding on duration and timing. It is possible, for instance, that potential benefits of short projects arise quickly but less durable than those of longer projects. For this reason we incorporate interaction of duration with the number of years into treatment, as follows,

[8] This methodology assumes that the potential effects are independent of time trends, and thus, all companies face the same effects over time. Therefore, the estimated effects should be the result of the program and not of time trends.

$$y_{it} = \alpha + \sum_{k=0}^{2}\sum_{j=0}^{5} \beta_j \, D^k \cdot D_{it}^j + \eta_i + \lambda_t + \varepsilon_{it} \qquad (5)$$

in which $D^k \cdot D^j_{it}$ are categorical variables that take value of one according to the duration of the project and number of years into treatment (Table 4).

Table 4 Number of years into treatment and length of the project

no. of years into treatment	Project duration		Total
	Short*	Long*	
1	16	36	52
2	10	24	34
3	4	17	21
4	2	10	12
5	1	6	7
Total	33	93	126

** Short project: 12 months or less; Long project: more than 12 months*

5.2 Results

5.2.1 Linear simple model

Table 5 shows the estimated coefficients of the simple linear model. Results suggest positive and significant potential effects (correlations) of Colciencias funding on labour productivity. The sign of sales and gross profit is positive as expected, indicating positive potential correlations with innovation policies. The negative coefficient of marginal productivity of capital and gross margin might be an indication of self-selection bias, in which companies that need radical improvements in their business processes might be those who are more likely to apply for Colciencias programs.

Table 5 Simple linear model

	Labour productivity	Marginal capital productivity	Sales	Gross profits	Gross Margin
Colciencias	0.136†	-0.178	0.274	0.257	-0.02
	[0.082]	[0.177]	[0.189]	[0.187]	[0.027]
Constant	11.207*	1.594*	15.673*	14.665*	0.421*
	[0.117]	[0.232]	[0.190]	[0.197]	[0.028]
Fixed effects	No	No	No	No	No
Time dummies	Yes	Yes	Yes	Yes	Yes
Observations	385	378	385	372	385

**Significant at 5%. †Significant at 10%*

All dependent variables are log-transformed (ln), except for gross margin (%)

5.2.2 Fixed Effects

After controlling for endogeneity all coefficients become positive, reflecting potential benefits of the Colciencias funding for innovation projects on firm productivity, revenues and efficiency (Table 6). In particular, we find significant evidence that Colciencias' innovation programs increase labour productivity by 24.2%. These benefits materialise in the second year after the funding was granted with increments in labour productivity of 35.3% on average.

Table 6 Fixed Effects Results

	Labour productivity			Marginal capital productivity			Sales			Gross profits			Gross Margin		
Colciencias	0.217*			0.2			0.174†			0.207			0.005		
	[0.079]			[0.194]			[0.089]			[0.130]			[0.042]		
1st year		0.131			0.134			0.09			0.111			-0.009	
		[0.084]			[0.175]			[0.085]			[0.122]			[0.047]	
2nd year		0.302*			0.095			0.190†			0.108			0.013	
		[0.105]			[0.201]			[0.103]			[0.161]			[0.045]	
3rd year		0.316			0.136			0.102			0.002			-0.036	
		[0.205]			[0.270]			[0.155]			[0.212]			[0.065]	
4th year		0.093			-0.542			-0.044			-0.394			-0.081	
		[0.189]			[0.348]			[0.217]			[0.312]			[0.106]	
5th year		0.153			-0.851†			-0.262			-0.570†			-0.026	
		[0.257]			[0.484]			[0.272]			[0.340]			[0.141]	
Short project			0.172			0.336			0.041			-0.011			-0.065
			[0.128]			[0.329]			[0.080]			[0.114]			[0.046]
Long project			0.160†			0.051			0.129			0.151			0.034
			[0.082]			[0.128]			[0.090]			[0.133]			[0.036]
Constant	11.182*	11.206*	11.202*	1.530*	1.551*	1.552*	15.615*	15.636*	15.634*	14.633*	14.659*	14.658*	0.417*	0.419*	0.417*
	[0.062]	[0.065]	[0.064]	[0.150]	[0.141]	[0.136]	[0.040]	[0.040]	[0.040]	[0.064]	[0.064]	[0.065]	[0.021]	[0.022]	[0.021]
Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	385	385	385	378	378	378	385	385	385	372	372	372	385	385	385
Number of firms	95	95	95	95	95	95	95	95	95	93	93	93	95	95	95

**Significant at 5%. †Significant at 10%*

All dependent variables are log-transformed (ln), except for gross margin (%)

Heterogeneous effects by duration and timing (Table 7) indicate that short projects produce the highest increase on labour productivity (61%) after its full implementation (on second year after receiving the funding).

Table 7. Fixed Effects Results - interaction effects

	Labour productivity	Marginal capital productivity	Sales	Gross profits	Gross Margin
Short project x					
1st year	0.101	0.181	-0.063	-0.113	-0.092
	[0.173]	[0.348]	[0.082]	[0.111]	[0.070]
2nd year	0.476*	0.236	0.161	0.073	0.005
	[0.133]	[0.426]	[0.142]	[0.211]	[0.057]
3rd year	0.073	0.78	0.11	-0.218	-0.144
	[0.241]	[0.652]	[0.304]	[0.171]	[0.127]
4th year	-0.209	0.328	0.686*	-0.255	-0.417*
	[0.157]	[0.353]	[0.153]	[0.196]	[0.079]
5th year	0.08	0.577	1.040*	0.292	-0.306*
	[0.195]	[0.428]	[0.188]	[0.251]	[0.101]
Long project x					
1st year	0.163	0.077	0.179	0.256	0.049
	[0.110]	[0.129]	[0.109]	[0.172]	[0.051]
2nd year	0.224+	-0.009	0.195+	0.126	0.023
	[0.119]	[0.161]	[0.114]	[0.185]	[0.049]
3rd year	0.377	-0.074	0.098	0.076	0.005
	[0.237]	[0.232]	[0.163]	[0.249]	[0.062]
4th year	0.147	-0.698+	-0.089	-0.328	-0.015
	[0.204]	[0.353]	[0.207]	[0.334]	[0.097]
5th year	0.139	-1.026*	-0.32	-0.593+	0.004
	[0.279]	[0.486]	[0.276]	[0.323]	[0.137]
Constant	11.205*	1.550*	15.630*	14.652*	0.419*
	[0.065]	[0.140]	[0.040]	[0.064]	[0.021]
Fixed effects	Yes	Yes	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes	Yes	Yes
Observations	385	378	385	372	385
Number of firms	95	95	95	93	95

**Significant at 5%. †Significant at 10%*

All dependent variables are log-transformed (ln), except for gross margin (%)

Fixed effects estimations also show weak positive average effects on sales revenue (Table 6). These benefits take some time to materialise and become strong and visible after four years of receiving funding for a short innovation project from Colciencias (Table 7). Increments on sales revenues can be as high as 98% on the fourth year into treatment, and more than 100% on the fifth year. The increase on sales seems to be translated in a decrease of gross margins. This occurs because gross profits remain constant, reflecting that the increase in sales also increased costs. It is important to note that very few of the short projects in the sample were approved more than four years before 2010 (Table 4). Therefore, these last results should be read with caution. A longer time spectrum might be required to confirm the effects on sales and gross profits.

6. Extensions

In this section we divide the sample in two groups to evaluate differential effects by firm size and Knowledge intensive business services (KIBS).

6.1 Firm Size

We defined two firm size groups in terms of number of employees. We defined as small companies those that reported 150 employees or less and large companies those with more than 150 employees.

6.1.1 Large Companies

We do not find significant average effects of the innovation policy on productivity, sales, profit or gross margin for large companies (Table 8). Some of the coefficients are negative and become significant after the third or fourth year, in particular, for gross profits and gross margin. It seems that this negative impact is derived from the financing of short projects for large companies. Therefore, the first impression is that public resources assigned to short projects for large companies do not produce real benefits for companies. However, with the interaction of years into treatment with project duration (Table 9), we find that the benefits of funding short projects for large companies materialise two years after their implementation, with increments in gross profits of 24.4% and in gross margins of 8.1%. Ambitious innovation projects undertaken and implemented by big companies in a short period of time might put some pressure in costs and sales reduction, making that initial results appear counter-intuitive.

Another interesting result is the negative coefficient of marginal capital productivity for short projects. During the first two years of implementation the effect is negative and significant, but, by the third year the sign flips and becomes positive (Table 9). Therefore, with the available information, this result is providing a first hint of potential benefits for marginal capital productivity that might take some time to become visible.

The overall effect of the funding for long projects awarded to large companies by Colciencias, on productivity, sales or efficiency is not significant. Negative significant effects arise after the fourth year into treatment (Table 9). Table 5 shows that only four long projects had been approved by Colciencias for a period longer than four years. Therefore, it might be necessary to have more observations from a longer time spectrum to draw final conclusions on the effects of the Colciencias funded long projects after their full implementation by large companies.

6.1.2 Small Companies

In contrast to the results for large companies, we find positive and significant effects of the Colciencias innovation policy on the labour productivity of small companies (Table 10). The funding granted by Colciencias to companies with less than 150 employees, increases their labour productivity by 23.1%. This positive effect becomes evident in the second year into treatment and seems to come from both short and long projects. Some weak positive effects on sales and gross profits are also visible.

Table 11 indicates that the benefits of Colciencias programs on labour productivity are mainly driven by the funding of short innovation projects. The increase in labour productivity in the year (second) immediately after implementation is 61% and on the following year (third) is 43.5%. Negative effects arise on the fourth year, this might be due to the lack of enough observations, as only two short projects had been founded by Colciencias before 2007 (Table 12). Therefore, this negative effect is relevant to very few projects and should be read with caution.

Table 8. Large companies. Fixed Effects Results

	Labour productivity			Marginal capital productivity			Sales			Gross profits			Gross Margin		
Colciencias	0.227			-0.432			0.026			-0.153			-0.021		
	[0.159]			[0.302]			[0.175]			[0.173]			[0.050]		
1st year		0.102			-0.201			0.055			-0.073			-0.046	
		[0.176]			[0.299]			[0.142]			[0.240]			[0.066]	
2nd year		0.185			-0.349			0.017			-0.389*			-0.062	
		[0.147]			[0.248]			[0.156]			[0.154]			[0.051]	
3rd year		0.072			-0.58			-0.045			-0.411			-0.108*	
		[0.174]			[0.359]			[0.198]			[0.265]			[0.053]	
4th year		0.084			-0.496			-0.127			-0.777*			-0.190*	
		[0.212]			[0.344]			[0.212]			[0.250]			[0.062]	
5th year		0.129			-0.900*			-0.048			-1.150*			-0.264*	
		[0.201]			[0.343]			[0.218]			[0.285]			[0.070]	
Short project			0.091			-0.586†			-0.384*			-0.582*			-0.056
			[0.350]			[0.303]			[0.089]			[0.221]			[0.052]
Long project			0.092			-0.051			0.096			-0.084			-0.036
			[0.106]			[0.231]			[0.087]			[0.107]			[0.037]
Constant	11.035*	11.077*	11.076*	1.595*	1.513*	1.512*	17.051*	17.051*	17.055*	15.924*	15.898*	15.912*	0.366*	0.365*	0.366*
	[0.066]	[0.058]	[0.057]	[0.188]	[0.178]	[0.156]	[0.075]	[0.062]	[0.057]	[0.111]	[0.118]	[0.123]	[0.029]	[0.029]	[0.030]
Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	147	147	147	146	146	146	147	147	147	144	144	144	147	147	147
Number of firms	42	42	42	42	42	42	42	42	42	41	41	41	42	42	42

**Significant at 5%. †Significant at 10%*

All dependent variables are log-transformed (ln), except for gross margin (%)

Table 9. Large companies. Fixed Effects Results with interaction effects

	Labour productivity	Marginal capital productivity	Sales	Gross profits	Gross Margin
Short project x					
1st year	-0.102	-0.718†	-0.459*	-0.814*	-0.146
	[0.625]	[0.372]	[0.125]	[0.294]	[0.088]
2nd year	0.312	-0.876*	-0.352*	-0.391*	0.016
	[0.297]	[0.271]	[0.090]	[0.171]	[0.046]
3rd year	-0.003	0.011	-0.002	0.218†	0.081*
	[0.073]	[0.108]	[0.040]	[0.118]	[0.028]
4th year					
5th year					
Long project x					
1st year	0.167	-0.079	0.182	0.154	-0.013
	[0.202]	[0.259]	[0.116]	[0.271]	[0.079]
2nd year	0.132	-0.148	0.153	-0.422*	-0.095
	[0.143]	[0.226]	[0.157]	[0.198]	[0.059]
3rd year	0.075	-0.479	0.061	-0.322	-0.109†
	[0.173]	[0.393]	[0.201]	[0.281]	[0.057]
4th year	0.1	-0.329	-0.032	-0.710*	-0.186*
	[0.232]	[0.363]	[0.216]	[0.247]	[0.072]
5th year	0.147	-0.736*	0.089	-1.018*	-0.257*
	[0.201]	[0.356]	[0.215]	[0.285]	[0.075]
Constant	11.075*	1.510*	17.051*	15.884*	0.360*
	[0.061]	[0.162]	[0.057]	[0.124]	[0.031]
Fixed effects	Yes	Yes	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes	Yes	Yes
Observations	147	146	147	144	147
Number of firms	42	42	42	41	42

**Significant at 5%. †Significant at 10%*

All dependent variables are log-transformed (ln), except for gross margin (%)

Table 10. Small companies. Fixed Effects Results

	Labour productivity			Marginal capital productivity			Sales			Gross profits			Gross Margin		
Colciencias	0.208*			0.285			0.184†			0.301†			0.026		
	[0.087]			[0.264]			[0.102]			[0.163]			[0.064]		
1st year		0.145			0.112			0.06			0.168			0.021	
		[0.093]			[0.255]			[0.102]			[0.152]			[0.072]	
2nd year		0.294*			0.099			0.22			0.29			0.067	
		[0.129]			[0.288]			[0.140]			[0.211]			[0.075]	
3rd year		0.261			0.142			0.066			0.161			0.042	
		[0.174]			[0.374]			[0.209]			[0.308]			[0.098]	
4th year		0.081			-0.871†			-0.13			-0.194			0.047	
		[0.231]			[0.512]			[0.287]			[0.467]			[0.157]	
5th year		0.092			-1.137			-0.311			-0.247			0.112	
		[0.295]			[0.700]			[0.340]			[0.489]			[0.211]	
Short project			0.233†			0.53			0.108			0.194			-0.03
			[0.128]			[0.424]			[0.091]			[0.168]			[0.070]
Long project			0.178†			-0.01			0.13			0.272			0.086
			[0.101]			[0.172]			[0.125]			[0.174]			[0.062]
Constant	11.277*	11.294*	11.287*	1.508*	1.536*	1.534*	14.755*	14.778*	14.771*	13.886*	13.915*	13.907*	0.445*	0.447*	0.444*
	[0.077]	[0.080]	[0.079]	[0.202]	[0.194]	[0.185]	[0.046]	[0.049]	[0.049]	[0.071]	[0.073]	[0.072]	[0.029]	[0.031]	[0.029]
Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	238	238	238	232	232	232	238	238	238	228	228	228	238	238	238
Number of firms	66	66	66	66	66	66	66	66	66	65	65	65	66	66	66

**Significant at 5%. †Significant at 10%*

All dependent variables are log-transformed (ln), except for gross margin (%)

Table 11. Small companies. Fixed Effects Results with interaction effects

	Labour productivity	Marginal capital productivity	Sales	Gross profits	Gross Margin
Short project	**x**				
1st year	0.119	0.238	-0.006	0.091	-0.056
	[0.151]	[0.424]	[0.108]	[0.152]	[0.094]
2nd year	0.479*	0.426	0.299	0.237	0.015
	[0.170]	[0.547]	[0.206]	[0.323]	[0.099]
3rd year	0.361*	1.006	-0.061	0.001	0.046
	[0.134]	[0.906]	[0.169]	[0.257]	[0.113]
4th year	-0.270*	-0.2	-0.378*	-0.629*	-0.136*
	[0.078]	[0.240]	[0.077]	[0.128]	[0.051]
5th year					
Long project	**x**				
1st year	0.167	-0.018	0.12	0.232	0.085
	[0.117]	[0.190]	[0.133]	[0.202]	[0.078]
2nd year	0.177	-0.133	0.174	0.32	0.09
	[0.145]	[0.208]	[0.153]	[0.199]	[0.073]
3rd year	0.21	-0.145	0.094	0.214	0.049
	[0.209]	[0.310]	[0.238]	[0.353]	[0.098]
4th year	0.06	-1.012*	-0.08	-0.11	0.069
	[0.249]	[0.489]	[0.295]	[0.468]	[0.148]
5th year	0.022	-1.344†	-0.378	-0.307	0.125
	[0.318]	[0.690]	[0.335]	[0.462]	[0.203]
Constant	11.297*	1.540*	14.776*	13.913*	0.446*
	[0.082]	[0.185]	[0.050]	[0.074]	[0.031]
Fixed effects	Yes	Yes	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes	Yes	Yes
Observations	238	232	238	228	238
Number of firms	66	66	66	65	66

**Significant at 5%. †Significant at 10%*

All dependent variables are log-transformed (ln), except for gross margin (%)

Table 12. Number of years into treatment and length of the project, by company size

no. of years into treatment	Small companies Project duration		Large companies Project duration	
	Short*	Long*	Short*	Long*
1	12	15	4	21
2	6	11	4	13
3	2	11	2	6
4	1	7	1	3
5	1	5		1
Total	22	49	11	44

** Short project: 12 months or less; Long project: more than 12 months*

6.2 Knowledge intensive business services (KIBS)

The majority of the firms in our sample (97%) are classified as knowledge intensive business services (Table 13). This is due to the design of survey. The NSS survey included companies classified in the ISIC sectors detailed in Table 1 only, for which most subsectors are knowledge intensive[9]. We cannot provide statistics on the proportion of KIBS companies that fall in each subactivity, because company registers are confidential DANE created a dummy variable indicating whether the company is a KIBS, according to a list (that we provided) with ISIC codes that correspond to activities classified as KIBS (Table 14).

Table 13 Number of companies by size and KIBS classification

	Company Size		KIBS	
Year	**Large**	**Small**	**yes**	**no**
2006	26	44	69	1
2007	25	45	69	1
2008	27	42	67	2
2009	32	52	81	3
2010	37	55	87	5
Total	***147***	***238***	***373***	***12***
Percentage	***38.2%***	***61.8%***	***96.9%***	***3.1%***

[9] This is consistent with the database provided by Colciencias in which the majority of companies are KIBS.

Table 14. ISIC codes corresponding to KIBS

Code	Description
I634	Activities of travel agencies and tour operators; tourist assistance activities n.e.c.
I639	Activities of other transport agencies
I642	Telecommunications
K721	Hardware consultancy
K722	Software publishing, consultancy and supply
K723	Data processing
K724	Database activities and online distribution of electronic content
K725	Maintenance and repair of office, accounting and computing machinery
K729	Other computer-related activities
K741	Legal, accounting, bookkeeping and auditing activities; tax consultancy; market research and public opinion polling; business and management consultancy
K742	Architectural, engineering and other technical activities
K743	Advertising
K749	Business activities n.e.c.
N851	Human health activities

6.2.1 KIBS

We find large and positive significant effects of the Colciencias programs on the labour productivity and sales of KIBS (Table 15). Obtaining funding for innovation projects increases the labour productivity of KIBS by 25.7% and their sales by 20.6%. The benefits on labour productivity occur in the second year after the funding was granted.

Differential effects by timing into treatment and project duration (Table 16) indicate that the positive impact on labour productivity mainly arises from short projects after full implementation (on the second year after the funding was granted), with an average increase of 62.4%. In addition, long projects show a positive but weakly significant effect on labour productivity on the second year into treatment and positive coefficients for the rest of the period. However, on the aggregate we find that financing long projects of KIBS contribute to increase their productivity by 17.8% (Table 15).

The positive effects on sales are very similar to those observed for the full sample, in which the increase in sales might also increasing costs, keeping gross profits constant and, thus, causing a decline in gross margins. However, as explained above, the proportion of short projects for which Colciencias funding was granted is very small and a longer time spectrum might be needed to observe positive and long-lasting effects on those measures.

6.2.2 Non-KIBS

The estimation of the non-KIBS model included only five companies and 12 observations. This number of observations does not provide sufficient information to provide reliable conclusions on the effects of the Colciencias innovation programs on companies classified as non-KIBS. However, there seem to be some benefits on labour productivity for short projects and in the second year into treatment. We find negative effects on sales, gross profits and marginal capital productivity which are mainly driven by financing projects of short duration (Tables 17 and 18).

Table 15. KIBS. Fixed Effects Results

	Labour Productivity			Marginal capital productivity			Sales			Gross profits			Gross Margin		
Colciencias	0.229*			0.222			0.187*			0.224			0.007		
	[0.081]			[0.199]			[0.091]			[0.135]			[0.043]		
1st year		0.141			0.156			0.103			0.133			-0.007	
		[0.087]			[0.181]			[0.088]			[0.127]			[0.048]	
2nd year		0.306*			0.115			0.196†			0.11			0.013	
		[0.108]			[0.204]			[0.105]			[0.165]			[0.046]	
3rd year		0.325			0.163			0.111			0.017			-0.033	
		[0.206]			[0.273]			[0.156]			[0.215]			[0.066]	
4th year		0.103			-0.506			-0.031			-0.375			-0.076	
		[0.191]			[0.350]			[0.218]			[0.314]			[0.107]	
5th year		0.159			-0.810†			-0.246			-0.544			-0.021	
		[0.259]			[0.486]			[0.273]			[0.343]			[0.142]	
Short project			0.187			0.369			0.054			-0.001			-0.07
			[0.135]			[0.348]			[0.084]			[0.121]			[0.048]
Long project			0.164*			0.066			0.133			0.158			0.035
			[0.082]			[0.129]			[0.091]			[0.135]			[0.036]
Constant	11.203*	11.228*	11.225*	1.551*	1.575*	1.575*	15.654*	15.678*	15.675*	14.666*	14.694*	14.694*	0.417*	0.419*	0.417*
	[0.062]	[0.065]	[0.064]	[0.151]	[0.142]	[0.137]	[0.041]	[0.040]	[0.041]	[0.064]	[0.064]	[0.065]	[0.021]	[0.022]	[0.021]
Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	373	373	373	366	366	366	373	373	373	361	361	361	373	373	373
Number of firms	90	90	90	90	90	90	90	90	90	89	89	89	90	90	90

**Significant at 5%. †Significant at 10%*

All dependent variables are log-transformed (ln), except for gross margin (%)

Table 16. KIBS. Fixed Effects Results with interaction effects

		Labour productivity	Marginal capital productivity	Sales	Gross profits	Gross Margin
Short project	**x**					
1st year		0.114	0.212	-0.056	-0.113	-0.102
		[0.188]	[0.376]	[0.088]	[0.120]	[0.075]
2nd year		0.485*	0.264	0.169	0.082	0.004
		[0.136]	[0.438]	[0.143]	[0.214]	[0.058]
3rd year		0.082	0.812	0.119	-0.204	-0.144
		[0.242]	[0.657]	[0.303]	[0.173]	[0.129]
4th year		-0.201	0.367	0.701*	-0.233	-0.415*
		[0.163]	[0.362]	[0.155]	[0.200]	[0.081]
5th year		0.081	0.618	1.063*	0.329	-0.301*
		[0.199]	[0.436]	[0.190]	[0.256]	[0.103]
Long project	**x**					
1st year		0.172	0.097	0.189†	0.279	0.054
		[0.111]	[0.131]	[0.110]	[0.175]	[0.052]
2nd year		0.221†	0.005	0.19	0.111	0.019
		[0.121]	[0.163]	[0.115]	[0.189]	[0.049]
3rd year		0.383	-0.049	0.101	0.081	0.005
		[0.239]	[0.234]	[0.164]	[0.251]	[0.063]
4th year		0.155	-0.663†	-0.083	-0.317	-0.012
		[0.206]	[0.356]	[0.209]	[0.337]	[0.098]
5th year		0.144	-0.986*	-0.308	-0.573†	0.009
		[0.281]	[0.488]	[0.277]	[0.326]	[0.137]
Constant		11.227*	1.574*	15.672*	14.688*	0.419*
		[0.065]	[0.142]	[0.040]	[0.065]	[0.021]
Fixed effects		Yes	Yes	Yes	Yes	Yes
Time dummies		Yes	Yes	Yes	Yes	Yes
Observations		373	366	373	361	373
Number of firms		90	90	90	89	90

**Significant at 5%. †Significant at 10%*

All dependent variables are log-transformed (ln), except for gross margin (%)

Table 17. non-KIBS. Fixed Effects Results

	Labour productivity			Marginal capital productivity			Sales			Gross profits			Gross Margin		
Colciencias	0.088			-0.311*			-0.492*			-0.517*			-0.02		
	[0.364]			[0.026]			[0.104]			[0.066]			[0.094]		
1st year		0.426			-0.309			-0.565*			-0.459			0.059	
		[0.000]			[0.000]			[0.000]			[0.000]			[0.000]	
2nd year		1.270*			-0.304*			-0.747*			-0.313*			0.255*	
		[0.200]			[0.068]			[0.078]			[0.056]			[0.007]	
3rd year															
4th year															
5th year															
Short project			0.088			-0.311*			-0.492*			-0.517*			-0.02
			[0.364]			[0.026]			[0.104]			[0.066]			[0.094]
Long project															
Constant	10.336*	10.231*	10.358*	0.259*	0.232*	0.181*	14.467*	14.450*	14.344*	13.361*	13.336*	13.267*	0.287*	0.259*	0.282*
	[0.080]	[0.033]	[0.015]	[0.000]	[0.011]	[0.006]	[0.017]	[0.013]	[0.011]	[0.014]	[0.010]	[0.004]	[0.019]	[0.001]	[0.005]
Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	12	12	12	12	12	12	12	12	12	11	11	11	12	12	12
Number of firms	5	5	5	5	5	5	5	5	5	4	4	4	5	5	5

**Significant at 5%. †Significant at 10%*

All dependent variables are log-transformed (ln), except for gross margin (%)

Table 18. non-KIBS. Fixed Effects Results with interaction effects

	Labour productivity	Marginal capital productivity	Sales	Gross profits	Gross Margin
Short project	**x**				
1st year	0.426*	-0.309	-0.565	-0.459*	0.059*
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
2nd year					
3rd year					
4th year					
5th year					
Long project	**x**				
1st year	-0.844*	-0.005	0.182†	-0.146†	-0.196*
	[0.200]	[0.068]	[0.078]	[0.056]	[0.007]
2nd year					
3rd year					
4th year					
5th year					
Constant	10.443*	0.181	14.326	13.279*	0.302*
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Fixed effects	Yes	Yes	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes	Yes	Yes
Observations	12	12	12	11	12
Number of firms	5	5	5	4	5

**Significant at 5%. †Significant at 10%*

All dependent variables are log-transformed (ln), except for gross margin (%)

7. Conclusions

The main objective of this study is to provide a thorough analysis of the impact of public funds that promote innovation practices and are administrated by Colciencias. We particularly evaluate the effects of this funding on the productivity of firms in the service sector in Colombia. We focus on the service sector due to its high importance in the economy as the main contributor to the gross domestic product.

We use two novel databases and estimate fixed effects models to assess the effects on labour productivity, the marginal productivity of capital, sales revenue, gross profits and gross margin. Fixed effects estimation allows us to control for unobservable characteristics of firms and correct for potential endogeneity.

Our main results find significant impacts in terms of labour productivity with average increments of 24.2%. Small companies and KIBS are the main beneficiaries of the innovation programs of Colciencias, with increments in their productivity in a range of 23% to 26%.

We analyse differential effects depending on the number of years after the funding was granted and the duration of the project. Projects that are implemented within a one year period (short projects) produce the largest increases (61% - 62%) in labour productivity. These benefits are evident after their full implementation, mainly in the second year after receiving the funds from Colciencias. The productivity of small companies also show increments of 43.5% in the third year into treatment, but in general, we do not find long-lasting effects for the following years for any case. This result might be partially due to the fact that very few projects were approved and received financial benefits in the first two years of the period studied (2006 and 2007). Therefore, it might be necessary to have a longer time spectrum, in order to draw final conclusions on the duration of the positive effects.

Financing long projects also seem to have positive effects on labour productivity. In most cases these effects are weak (significant at 10%) except for the case of KIBS. Long projects, partially funded by Colciencias and implemented by KIBS, increase labour productivity by 17.8%.

The beneficial impact of Colciencias funding on large companies is visible with the adoption of short projects that increase their gross margin by 8.1%. This results from an increase in gross profits, possibly due to a reduction in costs[10]. The implementation of these projects seems to be causing initial negative effects on the marginal capital productivity and gross profits. Therefore, it is likely that the type of innovation projects that large companies adopt might be of different nature that those of small companies.

In summary, this study contributes to the discussion of the benefits of public innovation programs on the productivity of companies that belong to the service sector. The results highlight the importance of those programs on improving labour productivity of all companies, but in particular those with less than 150 employees and classified as KIBS. This is an outstanding result as these type of companies are the ones with the highest potential to grow and can largely contribute to the economic development of the country. Finally, the Colombian innovation policy led by Colciencias is effectively targeting and benefiting the companies with the greatest need for funding (small and KIBS companies).

[10] As the effect on sales is not significant and has a negative sign.

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Centro de Investigaciones Económicas

Avda. Uruguay 1242 - Montevideo CP 11100 - Uruguay
Tel./ fax (598) 2900 3051 / 2908 1533 - E mail: cinve@cinve.org.uy
http://www.cinve.org.uy