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Abstract

This paper presents evidence on the spillover effect associated with the support received by firms located in a City of Argentina, between 2003 and 2007. The rationale for the cluster development program was the presence of agglomeration economies and coordination failures that generated spillovers and therefore to a suboptimal allocation of resources. We use a panel of firms in the ICT sector for the period 2003-2011 that allowed us to control for the dynamics of firms' sales and fixed-effect applying the System GMM estimator. We find that one additional participant in the program increases the sales of non-participants in the City of Córdoba by 0.7%.

Keywords: Cluster Development Program, Information and Communication Technologies, Spillovers, System GMM.

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1. Introduction

Governments in several countries are increasingly implementing public programs to support clusters with the objective of increasing productivity, increasing jobs, or developing certain industries. However, there is a strong debate on whether and how governments should support private firms (Crespi et al 2014). On the one hand, there are views resistant to public policy promotion of specific industries. These views argue for neutral interventions, and therefore propose horizontal policies in which firms of different sectors or regions can be beneficiaries. On the other hand, there are views proposing selectivity in the sectors to be supported. Cluster development programs are by nature sectoral and regional specific. Therefore they are supported only for those who stand for more selectivity. The economic rationality for these types of programs is the presence of agglomeration economies and coordination failures (Becattini 1989, Porter 1990, and Giuliani 2005) that lead to a suboptimal allocation of resources. Agglomeration economies, first documented in the work of Marshall (1920), are the result of a set of external positive factors emerging from the proximity between firms (Arrow 1962, Romer 1986, and Glaeser et al. 1992). Under the presence of these externalities, investment decisions are related each other and the investment of one firm may have a positive effect on the investment profitability of other firms (Rosenstein-Rodan 1943). The empirical literature on agglomeration economies began in the 1970s with the contributions of Shefer (1973) and Sveikauskas (1975). However, the work by Ciccone and Hall (1996) was the first to address the intrinsic endogeneity—i,e, do firms benefit from agglomeration because of externalities, or do rather the most successful and productive firms decide to locate close to other firms? According to their findings doubling the employment density increases average labor productivity by around 6 percent in United States gross state output. Other papers presenting evidence of agglomeration economies include Ellison and Glaeser (1997), Hanson (2001), Dumais et al. (2002), Rosenthal and Strange (2003), Rodríguez-Clare (2005, 2007), Combes et al. (2010, 2011), Rosenthal and Strange (2003), Rizov et al. (2012) and Moretti (2014).

The lack of agreement between the views in favor or against policies that select some sectors is in part due to the lack of rigorous impact evaluations of these policies. A non-exhaustive list of evaluations of productive development programs in Latin America includes Binelli and Maffioli (2007), Crespi et al (2011), Volpe et al (2011), Eslava et al. (2012a and 2012b), Figal et al (2012), Arráiz et al. (2013), Castillo et al. (2013), Arráiz et al. (2014), and Castillo et al (2014). Although these studies filled important knowledge gaps in several directions, most of them have focused on horizontal policies and on the benefits received by direct beneficiaries. Unfortunately, there are few papers addressing the effect on firms that do not participate in the programs, but might still obtain benefits through externalities generated by these programs. This is an important gap considering that many of these policies are often justified by the presence of such externalities or spillovers. The few exceptions are Figal et al. (2012) who assessed the impact of the support program to *Arranjos Produtivos Locais* (APL) in Sao Paulo and Minas Gerais in Brazil, and Castillo et al. (2014) who studied the effect of the innovation support program FONTAR in Argentina. These studies evaluated the effect of the programs both on direct and indirect beneficiaries. They considered different mechanisms to identify indirect beneficiaries. The former identified indirect beneficiaries as those firms that did not participate in the activities of the program, but were benefitted by being located in the same geographic area and produce in the same industry as the direct beneficiary firms. The second study identified indirect beneficiaries as those non-participant firms that hired skilled workers previously employed in a firm that participated in the program and therefore were able to transfer the knowledge provided by the program.

This paper aims at contributing to the literature by providing evidence on both a non-horizontal program and the spillover it created. The program was part of the *Development Program of Productive Chains in the Province of Córdoba* that occurred between 2003 and 2007. The program aimed at improving ICT firms' performance by financing up to 50% of joint projects prepared by ICT firms in the City of Córdoba. Joint projects generated local externalities that also benefited ICT non-participant firms in the City of Córdoba. For example, one of the joint projects was a purchasing pool to reduce costs. Participant firms reduced their cost and also sold inputs to non-participant. Similarly, the reputation gained by participants was freely shared to non-participants in the City of Cordoba because costumers identified ICT firms in Cordoba and not only those that participated in the program.

We use two databases in the empirical analysis: (i) the administrative records of the program, resulting from the monitoring activities carried out by the implementing agency and (ii) tax records, provided by the Statistics and Census Office of the Province of Córdoba, that provide us with sales information about every firm in the Province of Córdoba. The final dataset is an unbalanced panel of firms that allowed us to estimate the spillover effects controlling by fixed-effects and the previous dynamics of sales.

Our results indicate that the program was effective not only increasing the sales of the firms that actively participated in the program but also in increasing the sales of non-participant firms that received spillovers. In fact, we find that one additional participant increased the sales of non-participant ICT firms located in the City of Córdoba compared to other firms not located in the City of Córdoba by 0.7%.

The rest of the paper is organized as follows. Section 2 presents a brief discussion about Cluster Development Programs (CDP) and their rationale. Section 3 presents a detailed description of the policy program in the City of Córdoba. Section 4 discusses the identification strategy. This section presents the dataset used in the evaluation and the econometric methods applied to identify the spillover effects. Sections 5 and 6 present the empirical results and a robustness analysis. Finally, section 7 concludes.

2. The rationale of Cluster Development Programs

The definition of clusters is challenging in itself and several definitions have been proposed over time (Martin and Sunley 2003). A baseline definition interprets an industrial cluster to be a geographic group of interconnected firms and associated organizations specialized in the same or related production activities. This agglomeration generate industry- and location-specific externalities that range from the exchange of information and technological spillover improving innovation as a result of formal and informal networks among them and with their associated organizations, to the creation of a local labor market where appropriate skills can be found and contracted.

The network and linkages are in the core of industrial clusters. These linkages increase personal networking, facilitate repeated interactions that in turn may modify the terms of the exchange, facilitate knowledge transfer, facilitate organizational learning and act as a locus of innovation, strengthen the effects of economies of scale, facilitate the generation of public goods (Lundvall, 1988 and 1992).

Linkages evolve over time and ex-ante expectations of opportunistic behavior by the agents may change into mutual trust as agents accumulate experience and are embedded in a specific social context (Nooteboom 1992). The emergence of mutual trust among members is likely to considerably reduce transaction costs and improve the benefits of linkages. This mutual trust is more likely to occur within closely located firms where entrepreneurs can meet and develop informal linkages.

In addition to the strengthening of linkages, sharing a specific location also helps firms to hire workers trained in specific skills relevant to the industry. In fact, labor pooling generates externalities because the concentration of an industry in a certain location allows workers to specialize in industry-specific skills without the fearing of not finding a job that matches those skills in their area of residence. Moreover, the effect of agglomeration economies is also dynamic (Rodriguez-Clare 2005). For example, the concentration of specialized workers also increases the concentration of firms that aim at hiring workers with specific skills. Similarly, the interaction between firms encourages a higher rate of productivity growth which in turn facilitate a more intense and effective process of innovation and new interactions.

Although many linkages between firms already exist, they are often not sufficiently structured and firms fail to exploit their full potential beyond the realization of market transactions. In other cases, firms fail to set up linkages themselves or the linkages are not of the quality required to fulfill their potential. A number of factors, such as asymmetric information, may affect this failure.

In light of the benefits of effective business linkages and the externalities they create, many countries have been implementing policies and programs that aim at strengthening and improving these linkages and make them more beneficial and virtuous.

Several studies provide evidence of positive agglomeration economies. The empirical literature on agglomeration economies began in the 1970s with the contributions of Shefer (1973) and Sveikauskas (1975). However, the work by Ciccone and Hall (1996) was the first to address the intrinsic endogeneity in clusters. According to Ciccone and Hall (1996) a doubling of employment density increases average labor productivity by around 6 percent in United States gross state output.

The second rationale for CDPs is the presence of coordination failures that hamper the development of some industries in specific localities. Coordination failures are a widespread and a well-known problem in development economics that may lead to a remarkably suboptimal allocation of resources if not properly addressed by policy interventions. Production development is not alien to this problem and investment could strongly be affected by poor coordination. As pointed out by Rosenstein-Rodan (1943), coordination failures emerge in the presence of externalities that make the investment decision of one agent interrelated to those of others. In the case of productive investment, the investment of one firm can have positive effects on the profitability of the investment of another firm to the point that without the former the latter would not be economically viable.

Solving coordination failures is one of the key objectives of cluster development programs. These interventions create formal and informal institutional frameworks to facilitate private-private, public-private and public-public collaboration. To induce more collective action among private firms in a cluster programs often strengthen a local business association or help creating a new one or a new "cluster association" that firms may join as the common interest of firms in a that cluster may not coincide with existing sectorial-type business chambers.

Hence, the existence of information asymmetries, externalities and coordination failures represent the guiding principles and justification for CDPs that aim at strengthening linkages and improving their quality.

3. The Information and Communications Technology CDP in the City of Córdoba

Between 1998 and 2002 Argentina's economy plunged into a recession. Gross Domestic Product (GDP) fell 12 percent from 1998 to 2002, private investment was reduced by 32 percent, and at the beginning of 2002 industrial production was 18 percent lower than in the same period of 2001. The greatest impact was suffered by small and medium enterprises (SMEs). In this context, the Province of Córdoba—with the support of the Multilateral Investment Fund, BID-FOMIN—designed the Productive Chains Development Program with a budget of 1.9 million of dollars.

The program was based on a study aimed at selecting specific sectors that, due to their current characteristics and future perspectives, could take advantage from a program aimed at improving the competitiveness of SMEs in those sectors. The selected clusters were the Information and Communication Technologies (ICT) in City of Córdoba, the furniture production in Rio Segundo and Calamuchita, and the regional goods production in the northwest of the province. In the rest of the paper we focus our attention in the ICT cluster.

The City of Córdoba had important advantages for the development of the ICT cluster. These advantages included: access to every market in the country; the presence of air and land logistic services; adequate provision of electricity, natural gas, water, sewer services, telephone and Internet; as well as other elements that contribute to the infrastructure required by the industry. In addition, the city held a pool of highly educated labor, with 12 graduate programs in engineering, two of which were directly related to electronics and telecommunication. Citywide, there were close to 120,000 university students.

In 2002, the ICT cluster was formed by a group of more than 20 firms that adopted the name of the Cluster Córdoba Technology (CTC). The main objective of the cluster was the promotion of the development of new products and applications, as well as a concerted effort to integrate with international markets. In addition, a group of 37 firms and a university formed the Chamber of Computer, Electronic and Communications of Central Argentina (Cámara de Industrias Informáticas, Electrónicas y de Comunicaciones del Centro de Argentina, or CIIECCA). In addition to these groups of organized firms, there were close to 60—mostly informal—micro firms dedicated to software design. In several cases, they used to be suppliers of the other firms.

The program was implemented between July 2003 and October 2007 with the objective of increasing the firms' competitiveness. To reach this objective, the program strengthened the cooperation between firms and between firms and institutions to enhance and consolidate social capital, supported the access to productive and organizational technologies, and supported access to markets.

To participate in the program firms belonging to the ICT sector in City of Córdoba applied for the support by presenting a joint project. Joint projects included the application for credit with special conditions, the investment in capital goods, or strategic and logistic organization in the search for new markets. An important example of the cluster actions was the creation of a purchase pool of inputs that allowed firms to considerable reduce their costs. In fact, purchasing pool bought higher quantities at lower prices that allowed participating firms benefited from lower price of inputs. The purchasing pool also allowed to participating firms to sell inputs to non-participant at lower prices. This is a clear example of the coordination gains for the participants and also an example of spillovers to non-participant. Another example of the coordination benefits was the acquisition of quality certificates. The program allowed the access to quality certificates that could not have been obtained individually by each firm because they implied an investment too large for small and medium enterprises. An evaluation committee studied the proposal, and in case of being approved, the program co-financed the project. On average, projects were co-financed by 50 percent. The group coordinator, a businessperson elected by the firms, played a key role facilitating the communication between the evaluating committee and the firms. S/he helped to keep the group organized and prevented owners or firms' representatives from overburdened by administrative work in detriment of the tasks of their own enterprises.

The Program financed 35 joint activities in the cluster for an amount higher than USD 1.9 million. Each activity involved at least two firms. More than half of the activities were below USD 10,000. However, there were activities with a cost above USD 100,000. In terms of the type of activities, the support for the access to productive and organizational technologies concentrated 67% of the resources, see Table 1. The program supported 83 SMEs from the ICT cluster between 2003 and 2007. The entry of firms into the program was sequential. The number of firms that received some support per year was 34, 17, 35 and 2 in 2003, 2004, 2005, 2006 and 2007, respectively.

Table 1: Activities supported by the program

Activities	Number of activities	USD
Strengthening cooperation, through: (i) Promotion of the formation of human resources on issues related to business cooperation. (ii) Identification of obstacles inhibiting firm and sector competitiveness. (iii) Increased awareness about the benefits of developing collective activities. (iv) Identification of services that need cooperation with universities and other specialized institutions. (v) Established mechanisms for the joint search of financial resources. (vi) Sharing experience between the firms in the cluster.	6	456,000
Access to productive and organizational technologies, through (i) Diagnosis of common problems in technology and production organization. (ii) Identification and recruitment of consultants able to respond to the needs identified in their diagnoses. (iii) Implementation of joint projects in order to improve the performance. (iv) Production of new technologies and management practices.	9	1,300,000
Access to markets, through the promotion of technical assistance aimed at: (i) Identifying new markets and niches in order to expand sales opportunities, both national and international.	20	190,000

(ii) Adjusting the quality and design of products and services.
(iii) Training sales and marketing managers.

Total	**35**	**1,900,000**

Source: Authors elaboration with ADEC data.

4. Identification strategy

As mentioned above, the main rationale of cluster development programs is the presence of coordination failures and agglomeration economies that generate externalities—spillovers—and therefore leads to a suboptimal allocation of resources. When the externalities are positive, as it is expected from coordination failures and agglomeration economies, firms' investment is lower than the optimum level because investors only consider their own benefits when they take the investment decision. To measure these externalities, we estimate the effect of the program on non-participant firms which receive the benefits of the program due to their linkages to participant—we call these firms the indirect beneficiaries of the program. The indirect effect is usually ignored in evaluation studies by implicitly assuming that the effect on non-participants is zero. Therefore, this is the main contribution of our paper.

ICT firms located in the City of Córdoba have linkages that generate spillovers from the participant to the non-participant firms. In fact, the ICT sector is a knowledge intensive sector and in many of the owners or managers of ICT firms actively participate in universities where there is knowledge sharing with other ICT firms. An additional channel of spillovers in the case of the ICT cluster in City of Córdoba is the purchasing pool that was constructed that lowered prices not only for the participants. Although the purchasing pool was not exclusively for firms located in the City of Cordoba those firms were more likely to benefit due to transaction costs—information about its existence, trust or transport costs. Finally, another source of spillovers is the reputation that participants gained in international markets and freely shared with non-participants in the City of Cordoba. Therefore, given that firms located in the City of Cordoba in the ICT sector are those with a higher probability of receiving spillovers, we consider them as indirect beneficiaries.

To identify the spillover effect of the program is crucial to understand what would be the value of sales of indirect beneficiaries if they do not receive the spillovers. This value is a counterfactual that cannot be directly observed. Indeed, this is in fact the crucial problem in causal inference (Angrist and Pischke 2009). To estimate this counterfactual it is necessary a group of firms that in average would have the same value of sales as the indirect beneficiaries should they have not received the spillover—i.e. a control group.

The firms in control group need to fulfill two conditions. First, it is necessary that they do not participate in the program or receive spillovers. Therefore, we include those firms outside the City of Cordoba in the control group. In addition, given that part of the knowledge transfer occurs in universities, we select only those the cities in the Province of Córdoba with universities or branches of the universities in the City of Córdoba. These cities are Río Cuarto, Villa María, San Francisco, Marco Juarez, Bell Ville, and Villa Dolores. Second, it is necessary that in absence of the program firms the control group would have the same sales than firms receiving the spillovers. We will discuss this condition in detail in section 4.b.

a. Data and Descriptive Statistics

We use data from two different sources: (i) the administrative records of the program, and (ii) data collected by the Tax Bureau of the Province of Córdoba and managed for statistical purposes by the Statistics Bureau of the Córdoba Province (DGEC). DGEC data provided us with an annual panel for the period 2003-2011. This dataset includes the population of manufactures and services producers from the Province of Córdoba. While this dataset contains information about geographic location, age, the main product, and sales, the administrative records of the program provided us with information on the date firms received the support and the type of support received by them.

Table 2 presents the descriptive statistics of the main variables per firm location. Although most of the ICT activity occurs in the City of Córdoba, there are firms outside City of Córdoba that potentially can be used as a comparison group for the beneficiaries of the cluster activities. The only ICT industry with no activity outside the City of Córdoba is the Manufacture of computers, radios, television, and communication devices. Because of this reason we excluded this sector of our analysis. Given that there are only 3 participant and 11 non-participant firms in the City of Córdoba corresponding to this sector, this exclusion of was not a major problem for our study. Therefore we restricted the analysis to firms producing hardware or software industries classified as International Standard Industrial Classification of All Economic Activities (CIIU) 31, 33, and 72. We were able to match 38 participants in the City of Córdoba in these industries.[7] The second column presents information about the 515 ICT firms located in the City of Córdoba that received the spillovers—i.e. the indirect beneficiaries. Finally, the third group corresponds to the 102 ICT firms located outside of the City of Córdoba that will serve as a control group for the indirect beneficiaries. Therefore, final dataset is an unbalanced panel with 655 firms.

Table 2: Descriptive statistics

	Participants[(1)] (All of them were located in the City of Córdoba)		**Non-participants** Located in the City of Córdoba: Indirect beneficiaries		**Non-participants** Located in other cities[(2)] in the Province of Córdoba: Control firms	
	Mean	S.D.	Mean	S.D.	Mean	S.D
Number of firms	38[(3)]		515		102	
Average number of observations per firm	8.4		5.5		6.0	
Manufacture of machinery and electrical devices [(4)]	0.478	0.500	0.438	0.496	0.393	0.489
Computer services and related activities[(5)]	0.522	0.500	0.562	0.496	0.607	0.489
Age	8.15	6.52	5.47	7.35	6.57	6.26

[7] The program provided support to 88 firms. However, it was possible to match only 42 of those firms and 4 of them were not in the City of Cordoba—one was in Villa Maria and the rest in other provinces. There are two reasons that can explain why it was not possible to identify the other 46 firms. First, they might be in a simplified tax regime for small firms that do not declare sales for taxes. Second, they might be declaring other industries as their main industry. This is not a major problem for our study. First, our main focus is on the indirect beneficiaries not on the participants. Second, even if firms in the simplified regime are not in our dataset, this is valid both for the participant and non-participants. Finally, we are interested only in the ICT sector.

Annual Sales (thousands of Pesos)	2,839	4,235	989	2,919	596	1,296
Annual Sales Growth	0.312	3.07	0.237	2.13	0.245	1.88

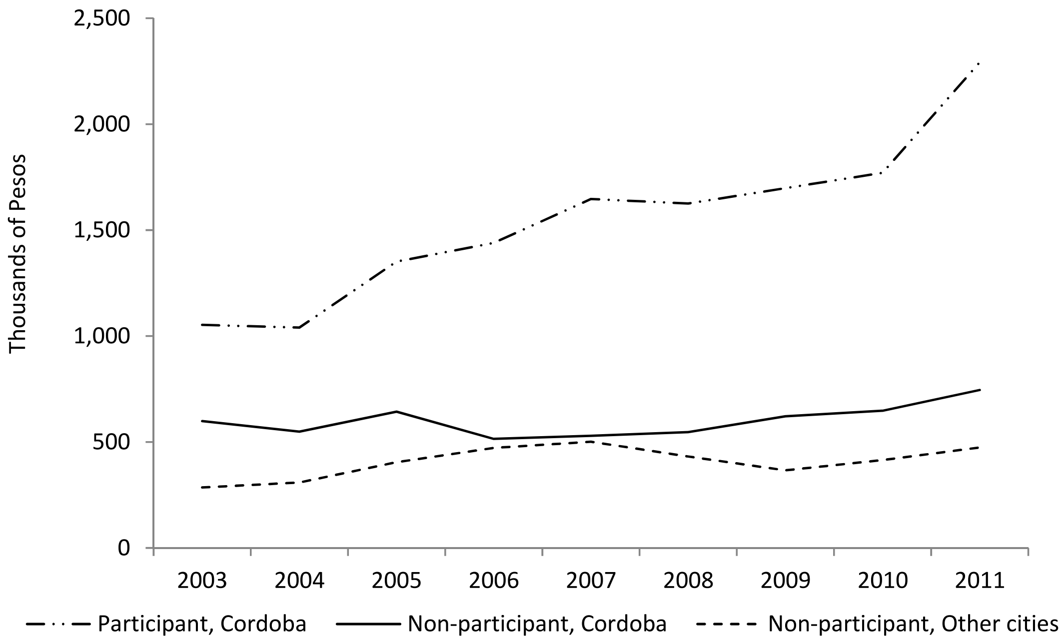
Notes: (1) There are 3 participants classified in CIIU 32 (Manufacture of computers, radios, television, and communications devices) that were not included in the analysis because there are no firms in other cities different from City of Córdoba. (2) Other cities include Río Cuarto, Villa María, San Francisco, Marco Juarez, and Bell Ville. (3) These are the participants that were matched to the DGEC in the two industries used in the analysis. (4) CIIU 31 and 33. (5) CIIU 72.

Table 2 shows that direct beneficiaries were larger and after they participated in the program increased sales at growing rates. In fact, the average annual growth of sales for the period 2003-2011 was 31%.

The comparability of indirect beneficiaries to control group can be observed from Table 2. In fact, it is possible to observe the same proportion of software and hardware firms in the City of Córdoba and in the rest of cities. Both non-participant in the City of Cordoba and non-participant in the rest of cities have approximately the same age, being the firms in the City of Cordoba one year younger than the firms in the rest of cities—5.47 years in City of Córdoba and 6.57 in the reset of cities. The structure of the panel is similar for the two groups of firms; in fact, we have information for approximately the same number of years—we have on average 5.5 years of information about non-participants in City of Córdoba and 6 years in the rest of cities. Finally, although indirect beneficiaries were larger, they grew on average at similar rate than firms in other cities—annual average of 23.7% for the firms in the City of Córdoba and 24.5%. Although that average is slightly lower for the firms in the City of Córdoba, this is not a signal of the absence of spillovers. In fact, given that they are on average larger and one year older, it is possible to expect lower rates. However, conditional on size and age, they could have larger growth. In fact, this is part of what we test in the empirical results.

Figure 1 shows the evolution of the average real sales—nominal sales deflated using the GDP deflator—for the participant firms in the City of Córdoba, non-participant in the City of Córdoba, and non-participant in other cities. This figure confirms that participants grew at higher rates than non-participants. In addition, the difference was large enough to be evident in the average value even when participants were larger and older and therefore with a lower growth profile.

Figure 1: The evolution of real sales of ICT firms



Notes: Nominal sales deflated using the GDP deflator. Other cities include: Rio Cuarto, Villa María, San Francisco, Marcos Juarez, Bell Ville, y Villa Dolores.

b. Econometric strategy

As we mention above, in a counterfactual scenario in which there are no spillovers, firms in the control group should have the same evolution of sales than indirect beneficiaries that receive the spillover effects. If the spillovers were randomly distributed across the firms in the Province of Córdoba, then the simple comparison of average sales growth would provide the effect of the spillover. However, even if the indirect beneficiaries did not apply to obtain the spillovers—the most common source of selection bias in the policy evaluation literature—they could be different than the firms in our control group because of two other reasons. First, firms in the City of Córdoba can take advantage of better infrastructure and business environment than firms in the rest of cities—this is valid even after selecting large cities with universities. Second, as a consequence of this better environment, firms in the City of Córdoba could also have better performance even without the spillover they receive.

The panel structure of our dataset allows us to tackle these two sources of bias. One estimator that it is usually used in the evaluation of productive development programs when there is panel data available is the fixed-effect estimator—see, for example, Arráiz et al (2013), Castillo et al. (2013), Arráiz et al. (2014), Castillo et al. (2014). This estimator works well when the selection into the program is due to unobserved variables. In our case, this estimator would help us to control for the effect of unobserved time invariant characteristics that could explain different evolution of sales between firms in the City of Córdoba and the rest of cities. For example, given that we do not expect large changes in infrastructure during the period of analysis, this estimator allow us to control for the effect of infrastructure. In fact this estimator not only allows us to control for the effect of infrastructure but also for any unobserved time invariant firm characteristic. For example, the size of the firm in 2003 before they receive the spillover, the type of society, the experience of the entrepreneur before joining or creating the firm, or the ability of the entrepreneur.

Let B_t be the total number of participants in the program and therefore the source of spillover effects, then the identification strategy requires that the expected value of sales of firm *i* in period *t* in the case where there is no spillovers, Y_{0it}, conditional to other firm characteristics, X_{it}, like the age of the firm and the type of product, and the unobservable firm-level time invariant characteristics, μ_i, to be independent of the number of participants and therefore to be independent of the spillovers; i.e. $E(Y_{0it}|, X_{it}, \mu_i, B_{it-1}) = E(Y_{0it}|X_{it}, \mu_i)$.[8] The estimating equation in this case is given by

$$Y_{i,t} = \delta B_{i,t-1} + \beta X_{i,t} + \mu_t + \mu_i + \varepsilon_{i,t} \qquad (1)$$

where $Y_{i,t}$ is the log of real sales and μ_t is a set of dummies that control for non-observed time varying factors that affect all firms in the same vain—for example, the economic growth or the inflation rate of the economy.[9]

If indirect beneficiaries have higher growth rate even in absence of spillovers, then equation (1) would produce (upward) biased estimates of the spillover effects. If this is the case, to identify the spillover effects it is necessary to control for the previous values of sales. The identification condition in this case is that the expected value of sales of firm *i* in period *t* in the case where there is no spillovers, Y_{0it}, conditional to other firm characteristics, X_{it}, and the lagged values of sales to be independent of the number of participants and therefore to be independent of the spillovers; i.e. $E(Y_{0it}|X_{it}, Y_{it-1}, B_{it-1}) = E(Y_{0it}|X_{it}, Y_{it-1})$. The estimating equation in this case is given by

$$Y_{i,t} = \delta B_{i,t-1} + \alpha Y_{i,t-1} + \beta X_{i,t} + \mu_t + \varepsilon_{i,t}. \qquad (2)$$

Angrist and Pischke (2009) show that if the correct identification assumption is the one used in equation (1), estimating equation (2) provides a lower value of the true effect. On the other hand, if the correct specification is the one used in equation (2), the estimation of equation (1) will produce a value larger than the true coefficient.

The fact that under incorrect specification equations (1) and (2) provide limits for the true value of the spillover effect is very useful. In fact, it is possible to control for both the fixed-effect and the previous evolution of sales. In this case, the identification assumption that the expected value of sales of firm *i* in period *t* in the case where there is no spillovers, Y_{0it}, conditional to other firm characteristics, X_{it}, the unobservable firm-level time invariant characteristics, μ_i, and the lagged values of sales to be independent of the number of participants and therefore to be independent of the spillovers; i.e. $E(Y_{0it}|, X_{it}, Y_{it-1}, \mu_i, B_{it-1}) = E(Y_{0it}|X_{it}, Y_{it-1}, \mu_i,)$. The estimating equation in this case is given by

$$Y_{i,t} = \alpha Y_{i,t-1} + \delta B_{i,t-1} + \beta X_{i,t} + \mu_t + \mu_i + \varepsilon_{i,t}. \qquad (3)$$

Under the assumptions described above, the estimation of equations (1), (2), and (3) is straightforward. Equation (1) can be estimated using the Within-Groups (WG) estimator,

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[8] We use the lag of the number of direct beneficiaries because we do not expect a contemporary spillover effect.

[9] It is possible to prove that controlling for this set of dummies is equivalent to deflating the value of sales by a price index for the ICT sector. Let P_{ICT} the price index of the ICT sector, then the real value of sales of firm i in period t is $sales_{it}/P_{ICT,t}$. Taking logs we have $Y_{it} = \log(sales_{it}) - \log(P_{ICTt})$, which is the variable in the left-hand side of (1). Note that $\log(P_{ICTt})$ does not vary at the firm level. Then adding $\log(P_{ICTt})$ in both sides of equation (1), the value of $\log(P_{ICTt})$ is controlled by μ_t.

equation (2) using Ordinary Least Squares (OLS), and equation (3) using the System GMM proposed by Blundell and Bond (2000). To estimate equation (3) it is also possible to use the Arellano and Bond (1991) difference estimator. However, we use the System GMM because the persistence of sales is large and Blundell and Bond (2000) shows that in those cases there is weak correlation between the level of sales and the difference in sales. Colombo et al (2013) used a similar framework to study the effect of public subsidies on the employment growth of new technology-based firms in Italy.

5. Empirical Results

Table 3 shows the estimates of the spillover effects obtained in each equation. We first present equation (2) because, as we mentioned above, if the model is misspecified, this equation will provide a lower value for the spillover effect; this lower value is 0.004, statistically significant at 1%. The second column shows the estimates of equation (1). If the correct identification assumption is the one related to the dynamics of sales rather fixed-effects, the estimated coefficient has an upward bias and provides an upper limit for the actual value of the spillover effect. The value of the spillover effect in this case is 0.056, statistically significant at 1%. Finally, the third column presents the estimates of equation (3) using the System GMM estimator. [10] The table also shows the Arellano–Bond test for first, second and third-order autocorrelation in the first-differenced errors. When the idiosyncratic errors are iid, the first-differenced errors are first-order serially correlated. However, if the model is well specified, there should not be autocorrelation of order superior than one; see Holtz-Eakin et at. (1988) and Arellano and Bond (1991). In addition, the table also presents Sargan test; under the null hypothesis the model is overidentified. Therefore, a rejection of this null hypothesis would imply reconsidering the model or instruments; see Arellano and Bond (1991). The System GMM estimate controls for both fixed-effects and lagged dependent variable and therefore is estimated under the correct identifying assumptions. As expected, the value of the coefficient is between the previous estimates.

Table 3: Estimation of the spillover effect

	Eq. (2) - OLS	Eq. (1) - FE	Eq. (3) - SGMM
B t-1 (Number of participants)	0.004***	0.056***	0.009***
	(0.002)	(0.010)	(0.002)
Log sales t-1	0.879***	-	0.236***
	(0.021)		(0.075)
Age and Age squared	Yes	Yes	Yes
Firm-level fixed effects	No	Yes	Yes
Industry fixed effects	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes
Sargan test (p-value)			45.90 (0.150)
Autocorrelation of order 1 (p-value)			-3.793 (0.000)
Autocorrelation of order 2 (p-value)			1.255 (0.209)

[10] The instruments we used in order to run the System GMM are the logarithm of sales from lag 2 onward for the equation in differences and the logarithm of sales with lag 7 for the level equation, in addition we consider as a general instruments the lagged value of the age and its squared, dummies variables associated with the industry heterogeneity, year and the interaction of them.

Autocorrelation of order 3 (p-value)			-0.688 (0.492)
Number of observations	2619	3259	2619
Number of firms	617	617	617
Instruments			47
R square	0.78	0.31	--

Notes: (i) Robust standard errors in brackets. (ii) ***, **, * statistically significant at 10, 5, and 1 percent.

The value of the coefficient estimated using System GMM is equal to 0.009, statistically significant at 1%. The coefficient can be interpreted as follows: one additional participant increases the sales of non-participants in the City of Córdoba by 0.9% on average in a year. Both the the Arellano-Bond autocorrelation tests and the Sargan test provides evidence of that the model is well specified.

6. Robustness checks

Table 3 controls for time-varying unobservable factors that affect all the firms in the same vein. In this section, we relax the assumption controlling for time-varying unobservable factors that might affect differently to firms in the software industry to those firms in the hardware industries. For example, this is the case if we use different deflator for each industry or different trend in growth between these industries. To control for these factors we include the interaction between the two industry dummies and the year dummies.

Table 4 shows the results of this estimation. Once again, the spillover effect is positive and statistically significant. As mentioned, equations (2) and (1) provide the lower and upper limits for the true parameter obtained in equation (3).

The value of the coefficient is slightly lower that in Table 3. In fact, is only 0.002 lower than in Table 3 and it is also statistically significant at 1%. This estimate implies that an additional participant increases the sales of indirect beneficiaries in 0.7%. The specification tests for the System GMM estimates also provide evidence of a well specified model.

Table 5: Estimation of the spillover effect. Robustness check

	Eq. (2) - OLS	Eq. (1) - FE	Eq. (3) - SGMM
Bt-1 (Number of participants)	0.004*	0.059***	0.007***
	(0.002)	(0.010)	(0.003)
Log sales t-1	0.880***	-	0.310***
	(0.021)		(0.072)
Age and Age squared	Yes	Yes	Yes
Firm-level fixed-effect	Yes	Yes	Yes
Industry fixed-effect	Yes	Yes	Yes
Year fixed-effect	Yes	Yes	Yes
Industry-year fixed effect	Yes	Yes	Yes
Sargan test			21.559 (0.307)
Autocorrelation of order 1 (p-value)			-4.143 (0.000)
Autocorrelation test. Order 2 (p-value)			1.380 (0.168)
Autocorrelation test. Order 3 (p-value)			-0.701 (0.481)
Number of observations	2619	3259	2619
Number of firms	617	617	617
Instruments			36
R square	0.777	0.314	--

Notes: (i) Robust standard errors in brackets. (ii) ***, **, * statistically significant at 10, 5, and 1 percent.

7. Conclusions

This paper estimates the spillover effect of the support received by ICT firms in the City of Córdoba under a Cluster Development Program implemented between 2003 and 2007. The program financed on average 50 percent of joint projects that helped to easy coordination failures and generated externalities. The spillovers were industry and location specific and therefore we defined as indirect beneficiaries to those firms in the ICT sector located in the City of Córdoba and compared them to ICT firms in other cities. Our results provide strong evidence on the existence of spillover effects. In fact, our estimates show that one additional participant in the program can generate spillovers that increase the sales of non-participant in the City of Córdoba by 0.9%.

We used data from the administrative records of the program and DGEC that allowed us to construct a panel of firms from 2003-2011. This dataset allowed us to use the panel structure to identify the spillover effects. Given that the value of sales of firms in the City of Córdoba compared to firms in other cities could change due to the different infrastructure and this different infrastructure could in fact imply differences in the growth of sales even before the firm receive the spillovers, we use the System GMM estimator that allows us to control for firm level unobserved time invariant characteristics and the lagged value of sales.

Our results have three important policy implications. First, they provide rigorous evidence about the existence spillover effects and therefore about the main rationale of cluster development programs. Second, they suggest that a larger program with more participant firms can lead to higher sales for other non-participant firms. These implications are linked. In fact, is the spillovers are not included in the design and ex-ante cost benefit analysis it is likely to have an under sized program. Third, an important implication is the type of data that needs to be collected during the implementation of the program. We were able to do the analysis because the program collected monitoring data on who participated in the program, in which activities, when, and how much received, and because we were able to use secondary data on sales. Although sales was in the core of the program objective, it would be also interesting to see the effect on other variables like employment, exports, and productivity. The need of that data for the evaluation has to be taken into account in the design and implementation of program.

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