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Cluster Initiatives and Economic Resilience: Evidence from a Technology Cluster in Argentina*

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Abstract

In this paper, we study the role of a cluster initiative in fostering economic resilience among firms in a local technology cluster in Argentina. We focus on two aggregate shocks that hit the Argentine economy, including first wave of the COVID-19 pandemic. Our analysis is based on interviews with authorities and members of the cluster initiative, local firms, and policy makers, as well as on firm-level administrative tax records. We find that the cluster organization provides members with resources that could foster resilience, including access to specialized human capital, information on business opportunities, and assistance in applying for government support programs. However, while members of the cluster organization appear to be more resilient than non-members, even within the same regional cluster, after conditioning on firm characteristics we find little evidence of a positive association between belonging to the cluster organization and economic resilience. Members of the cluster organization are neither less likely to exit nor adapt by switching their main economic activity and did not show statistically significantly higher revenue growth than non-members. Member firms do appear to have been more able than non-members to keep up with tax obligations during the first wave of the COVID-19 pandemic.

Keywords: Cluster initiatives, resilience, technology clusters, information technology industries, COVID-19 crisis.

JEL classification: R12, D22, D02

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1 Introduction

While a large number of cluster initiatives have emerged worldwide, relatively little is known about how they shape industrial clusters and drive firm outcomes. We contribute to improving this understanding by investigating the role of a cluster initiative in fostering economic resilience within a local cluster in Argentina. Specifically, we study the experience of the Córdoba Technology Cluster (CTC), the first privately led technology cluster organization in Argentina, formed by firms in IT sectors in the City of Córdoba, the largest metropolitan area in the country.

To understand the functioning of the cluster organization and its potential role in fostering economic resilience among its members, we conduct semi-structured interviews with authorities and members of the CTC, non-member firms in the local industrial cluster, and policy makers. Then, we exploit firm-level administrative records, including firms' sales, tax payments, and export status, to estimate the association between belonging to the cluster organization and economic resilience, comparing the performance of CTC member firms to similar firms outside the organization within the same local cluster. In particular, we focus on two relevant and recent macroeconomic shocks: the economic crisis that hit Argentina during the first quarter of 2018, following an increase in the U.S. interest rate and a nominal devaluation of the Argentine peso, and the first wave of the COVID-19 pandemic during the first half of 2020.

Our analysis requires precise definitions of what we mean by cluster initiative, regional cluster, and economic resilience. First, we follow Sölvell, Lindqvist, and Ketels (2003) and Lindqvist, Ketels, and Sölvell (2013) and define cluster initiatives as "organized efforts to increase growth and competitiveness of clusters within a region, involving cluster firms, government, and/or the research community".[1] Below we show that the CTC falls under this categorization. Second, following Porter (1990), we start by defining a regional cluster as a "group of interconnected firms, suppliers, related industries, and specialized institutions in particular fields that are present in particular locations".[2] We complement this general definition with more precise geographical and sectoral boundaries. To define industry boundaries, we use the industry composition of firms belonging to the cluster initiative. The CTC states that the organization is open to firms active in technology, software development, computing, telecommunications, electronics, services, and professional business services related to the value chain of technology development. We thus consider a cluster of IT-related industries at a fine level of aggregation. The geographical dimension of our definition is restricted to the City of Córdoba. This is not only determined by the data, which is restricted to firms who pay taxes there, but is also consistent with prior initiatives which identify the City of Córdoba as the relevant geographical unit to define a cluster of software development and IT services (Boneu et al., 2016; Gutman, Gorenstein, and Robert, 2018). Regarding economic resilience, we

[1] Throughout the paper, we use the terms "cluster initiative" and "cluster organization" interchangeably.

[2] The quote is from the introduction to Porter (1998).

focus on resilience at the level of individual firms and take a broad view on the concept, understanding it as the ability to cope with the consequences of negative economic shocks, in line with previous literature (Martin, 2012; Martin and Sunley, 2015; Martin, Mayer, and Mayneris, 2017; Dai et al., 2021; Behrens, Boualam, and Martin, 2020; Delgado and Porter, 2021). Consistent with this definition, in our econometric specifications we employ four measures of economic resilience: firm exit, revenue growth, the probability that a firm changes its main economic activity, and the ability of a firm to keep up with local tax payments.

A cluster initiative might develop several mechanisms that could drive the resilience of businesses given the definition of resilience we consider. First, cluster initiatives build networks that bring together firms and other stakeholders. This can improve cooperation, information sharing, knowledge flows, and access to new business practices through events such as seminars or training activities, which can improve firms' skills and their ability to cope with shocks. Second, business development activities are typical of cluster initiatives. These include business rounds, export promotion activities, joint purchasing, or shared access to services. Business development activities can reduce costs, diversify firms' product scope, and increase scale. Third, cluster organizations are involved in activities to shape or improve the business environment, including the regulatory framework, physical infrastructure, or the design and implementation of industrial policy. This can foster resilience through, for instance, lower taxes, improved connectivity, or government support programs. Notwithstanding these potential mechanisms, note that developing resilience is typically not considered an explicit objective of cluster initiatives per se in the literature (Lindqvist, Ketels, and Sölvell, 2013).[3]

The evidence resulting from the interviews conducted for this paper suggests the cluster initiative does provide its members with resources, benefits, and mechanisms that could result in more resilience among members compared to non-member firms within the same regional cluster. Consistent with the literature, these include discounts from suppliers, access to specialized human capital, business rounds and networking with potential clients, assistance when applying to government-sponsored promotional regimes, and formation of information-sharing networks. The cluster organization also maintains solid links with universities, local policy makers, and other

[3]In their study of cluster initiatives, Lindqvist, Ketels, and Sölvell (2013) list the following ten objectives that clusters may have: identity and brand, strategy and vision, innovation and R&D, business environment, growth and investment, HR upgrading, export promotion, value chain development, HR supply, and joint purchasing. Their results indicate that the most highly rated objectives are creating a cluster identity and building a brand, and building a strategy and vision for the cluster.

cluster organizations in Argentina, through which it affects the design and implementation of policies targeting the IT sector, including those aiming at increasing the supply of human capital. Some of these features may benefit firms during crises. For instance, during the COVID-19 pandemic, the organization maintained active communication channels through which members could share information to pool resources or learn about business opportunities associated with retail firms going online. Nevertheless, members do not seem to identify developing resilience as a mandate or explicit aim of the organization.

In reduced form econometric exercises, however, we cannot find evidence of a positive relationship between membership in the cluster organization and firm resilience. In principle, members of the cluster organization appear to be more resilient than non-member firms in the same regional cluster based on measures such as firm survival, revenue growth, ability to stay in their core economic activity, and ability to keep up with tax obligations. Yet, once we control for variables indicative of firm size and productivity, they no longer show an advantage along these variables, with the exception of honoring tax payments. These results apply both to "normal" times and the crisis periods we consider. These results suggest that, despite the potential to set up mechanisms that can foster economic resilience among firms, cluster initiatives may not automatically lead to higher resilience.

A drawback of our quantitative strategy is the inability to control for spillovers. We learn from interviews that some of the initiatives of the CTC could potentially affect the resilience of firms that do not belong to the organization. For example, many conferences and training events with sector specialists are open to non-members. Government policies targeting the sector, while influenced by the organization, can be enjoyed by any firm that meets eligibility criteria, independently of their membership in the CTC. If these activities contribute to firm resilience, then our estimates will be biased downwards and will underestimate the relationship between membership in the CTC and resilience.

This paper is related to the literature on cluster resilience and the role of cluster initiatives in supporting or developing firm capabilities. First, several papers document experiences of cluster development programs implemented in Latin America and the Caribbean sponsored by international organizations (Pietrobelli and Rabellotti, 2003; Pietrobelli and Stevenson, 2011; Maffioli, Pietrobelli, and Stucchi, 2016). In many of these cases, and with the explicit intention of promoting collective action among firms in the same regional cluster, policies have aimed at strengthening the association of local firms, helped create business associations, or created cluster initiatives that companies could join. However, Rocha (2015) and Maffioli, Pietrobelli, and Stucchi (2016) conclude that these policies have not been as successful as in

other countries or regions, partially due to the lack of governance mechanisms and the low degree of collective efficiency and joint action of the cluster. We find that the cluster initiative we study has been successful in creating an environment in which firms can form knowledge networks and find new business opportunities, as well as in influencing the design and implementation of public policies. However, the initiative has not been able to significantly affect the production of human capital with specific skills.

Second, we study a technology cluster, which includes predominantly services sectors, complementing the previous literature which, with few exceptions, has had manufacturing as the dominant focus when analyzing cluster policies and cluster resilience (Pietrobelli and Rabellotti, 2003; Maffioli, Pietrobelli, and Stucchi, 2016; Behrens, Boualam, and Martin, 2020; Martin, Mayer, and Mayneris, 2017). This is relevant considering the contribution of software and IT services to the digital transformation of firms, and could it potentially allow us to understand whether technology clusters can play a role as catalyzers of digitalization by providing resilience during crises. Our results, however, do not suggest the presence of sector-specific mechanisms affecting the functioning of the cluster initiative nor its effects on firm resilience.

Third, although our approach focuses on a cluster initiative *within* a regional cluster, our results can be compared with recent papers that find mixed evidence of a positive association between being located in a regional cluster and resilience at the level of the firm or plant during crisis. Martin, Mayer, and Mayneris (2017) study resilience in export markets during the 2008–2009 financial crisis among French exporters that benefit from the competitiveness cluster policies. They find that, while beneficiaries of cluster policies are more likely to survive in foreign markets and experience faster export growth than other exporters in normal times, this resilience is actually weaker during the crisis. Behrens, Boualam, and Martin (2020) look at textile and clothing clusters in Canada between 2001 and 2013, and, in general, find a weak association between locating in a regional cluster and resilience at the plant level. In particular, following the 2005 removal of import quotas at the end of the Multifiber agreement, they find that affected plants located in clusters were less likely to exit the cluster or die, but this advantage disappeared after two years. Dai et al. (2021) find a positive association between clustering and resilience during the first wave of the COVID-19 pandemic in China. Despite infection rates being higher in counties with higher clustering, these counties showed lower reductions in the firm entry rate than counties with lower clustering.

Finally, in a closely related paper, Boneu et al. (2016) study the performance of firms belonging to the CTC in the aftermath of the 2002 crisis. Their focus is not

on resilience, however. Instead, they study the impact of a productive development policy aimed at firms that were members of the cluster initiative. Our approach differs from that study in a number of ways. First, we are able to study resilience during crisis episodes, while they study a post-crisis scenario. Second, in our period there is not a particular policy affecting firms that belong to the cluster initiative, which could confound effects of the policy from other effects associated with the benefits of belonging to the cluster organization. Moreover, Boneu et al. (2016) consider all firms and apply a broader definition of regional cluster, while we exploit sales data for different economic activities declared by firms, precisely accounting for potential changes in the relative importance of firms' activities over time.

The rest of the paper is organized as follows. The next Section provides conceptual definitions of cluster initiatives, clusters, and resilience that frame the analysis that follows. Section 3 includes some background about the City of Córdoba as a local technology cluster in Argentina and the CTC cluster initiative. In Section 4, we approach the analysis of resilience by presenting qualitative evidence of the mechanisms that could give CTC firms an advantage over non-members, based on interviews with industry participants. Section 5 describes our quantitative approach to test the insights derived from the previous Section, and presents and discusses our main quantitative results. Section 6 concludes the paper.

2 Definitions

In order to evaluate the role of a cluster initiative in fostering economic resilience within a regional cluster, we need to provide appropriate definitions of cluster initiative, regional cluster, and economic resilience. This Section includes these definitions, which provide the conceptual framework for our empirical analysis below.

2.1 Cluster Initiatives and Technology Clusters

Following Sölvell, Lindqvist, and Ketels (2003) and Lindqvist, Ketels, and Sölvell (2013), we consider a cluster initiative or organization as an organized effort to increase growth and competitiveness of clusters within a region, involving cluster firms, government, and/or the research community.[4] According to the CTC, firms belonging to the organization "keep a high level of competitive rivalry, but also cooperate to improve the competitiveness of all of them by reaching agreements,

[4]The U.S. Cluster Mapping Project uses a similar definition. See https://clustermapping.us/content/glossary-terms.

forming strategic alliances, and seeking and receiving investments proposals."[5] The description of the CTC in Section 3 provides further evidence that supports the identification of the CTC as a cluster initiative.

Second, we need an operational definition of regional cluster to precisely identify a delimited control group of firms that, while not being part of the cluster initiative, share common attributes related to belonging to the same regional cluster. In Porter (1990), a regional cluster is understood as a geographically proximate group of interconnected companies and associated institutions in a particular field, linked by commonalities and complementarity.[6] For the aim of this paper, this general definition needs to be complemented by more precise geographical and sectoral boundaries, as highlighted in Behrens (2016) and Delgado, Porter, and Stern (2016). The geographical dimension of our definition is predetermined by the location of the cluster organization and is restricted to the City of Córdoba.[7] This is consistent with prior initiatives to fund cluster development programs in the Province of Córdoba, which identified the City of Córdoba as the relevant geographical unit to define a regional cluster associated to the CTC.[8]

To define industry boundaries, our criterion is to define a sub-group of industries based on the industry composition of firms belonging to the cluster initiative. On its website, the CTC states that the organization is open to firms active in technology, software development, computing, telecommunications, electronics, services, and professional business services related to the value chain of technology development. Moreover, in interviews conducted for this paper, CTC authorities stated that, in order to become members, firms must be part of the technology value chain, which they described as including mostly software development, but also hardware manufacturing, telecommunications, and IT consulting.

Beyond what the organization describes, we confirm the industry composition of the CTC by inspecting members' primary economic activity. Table 1 shows the industry composition of the CTC as of 2016, based on members' primary economic activity, defined as the activity with the highest revenue share.[9] Firms' activities

[5] See https://www.cordobatechnology.com/ctc/que-es-el-cluster.

[6] See also the introduction to Porter (1998).

[7] Data limitations prevent us from including firms in other regions of the Province of Córdoba, which could potentially be considered as part of the same regional cluster.

[8] Between 2003 and 2007, the Multilateral Investment Fund of the Inter-American Development Bank Group supported a cluster development program in the Province of Córdoba aimed at the IT sector, and identified the City of Córdoba as the relevant geographic unit characterizing the cluster. See Boneu et al. (2016).

[9] As we explain in Section 5, to minimize endogeneity issues in our quantitative analysis, we define membership in the cluster initiative based on 2016 data.

are registered at the 8-digit level according to an industry classification developed by the Directorate of Data and Statistical Analysis of the City of Córdoba. Under this classification, there are 933 8-digit economic activities.[10] All but two members (whose primary activity was in manufacturing) had their primary economic activity in services and commerce sectors. In particular, "Software development" and "Business services n.i.e." concentrate the majority of members, with 53% and 25%, respectively. Almost all economic activities in Table 1 fall within the technology value chain. Thus, we define the technology cluster as encompassing the activities in Table 1 with the exception of "Cleaning services" and education-related activities. This selection is consistent with clusters identified by Delgado, Porter, and Stern (2016) for the U.S. In particular, it includes their clusters "Information technology and analytical instruments," "Communications equipment and services," and "Business services."

To quantify the spatial agglomeration of these activities in the City of Córdoba, we compute location quotients at the department (municipality) level. Specifically, if L_{sd} is total employment in department d and industry grouping s, the location quotient a is defined as

$$LQ_{sd} \equiv \frac{L_{sd}/L_d}{L_s/L}, \tag{1}$$

where L_d is total employment in department d, L_s is total employment in grouping s, and L is total employment in Argentina. To compute LQ_{sd} we use formal employment data at the department level derived from social security administrative records for 2015. Economic activities are defined based on the ISIC Rev. 4 at the 5-digit level. We compute location quotients for an industry grouping that includes industries belonging to our definition of technology cluster. Table 2 presents the results for the 10 departments with the highest location quotients. The "Capital" department in the Province of Córdoba, which corresponds to the City of Córdoba, has a location quotient of 1.07 and is third in the ranking of location quotients for the 138 departments for which we have data, indicating that this group of industries is relatively more concentrated in the city than nationwide. This supports the identification of the City of Córdoba as a relevant regional technology cluster.

2.2 Economic Resilience

In a thorough study about the concept of economic resilience, Martin and Sunley (2015) provide qualitative definitions for different types of resilience, related to the

[10] For reference, the United Nations' International Standard Industrial Classification (ISIC) Rev. 4 contains 292 4-digit activities (classes).

Table 1: CTC Industry Composition, 2016

Industry code	Description	Number of firms
Services industries		
37300000	Software development	59
91100000	Business services n.i.e.	28
74300010	Advertising services	2
74993000	Call center services	2
80210020	Private education, tertiary	2
80900010	Education institute	1
45290000	Civil engineering	1
52395210	Mobile phone services	1
64209900	Sound, video, and data transmission services	1
64209910	Internet and electronic mail services	1
65990800	Financial intermediation services	1
74930000	Cleaning services	1
74991010	IT and software consulting services	1
91100100	Professional business services	1
Commerce industries		
51399950	Wholesale of products n.i.e.	3
51592100	Wholesale of IT equipment and office machines	2
52395000	Retail of office machines, computers, and replacement parts	1
52395010	Retail of IT supplies	1
52620000	Repair of electric housewares	1
Manufacturing industries		
29309940	Manufacturing and repair of computing equipment	1
30000000	Manufacturing and repair of computers and office machines	1

Note: This table shows the industry composition of the CTC as of 2016, based on members' primary economic activity.

ability of a system to absorb a shock with or without changing the fundamental nature of its function, structure, and identity. They conclude, however, that there is no universally agreed definition of regional or local resilience, nor a generally

Table 2: Location Quotients for Selected Departments in Argentina, Technology Cluster Industries, 2015

Province	Department	L_d	L_{sd}	LQ_{sd}
City of Buenos Aires	City of Buenos Aires	2,070,428	83,682	2.35
Tucumán	Tafí Del Valle	7,750	148	1.11
Cordoba	Capital	253,941	4,666	1.07
Santa Fe	Rosario	228,327	3,582	0.91
Buenos Aires	Tandil	18,665	280	0.87
San Luis	La Capital	33,612	504	0.87
Mendoza	Capital	60,948	825	0.79
Córdoba	General San Martín	17,582	237	0.78
Chaco	San Fernando	46,396	613	0.77
Mendoza	Luján De Cuyo	36,419	375	0.60
La Rioja	Capital	20,953	201	0.56
Buenos Aires Province	General Pueyrredón	103,271	958	0.54
Buenos Aires Province	San Isidro	127,915	1,083	0.49
Buenos Aires Province	Tres Arroyos	7,178	56	0.45
Buenos Aires Province	La Plata	81,701	632	0.45

Note: This table presents the top 15 departments with the largest location quotients in Argentina using formal employment data for 2015. The industry grouping includes all industries belonging to the definition of technology cluster in the text. Column L_d includes total employment in each department, column L_{sd} includes total employment in each department for this particular industry grouping, and column LQ_{sd} includes location quotients.

accepted methodology to measure it. Similarly, Bristow and Healy (2020) refrain from advancing a unique or common definition of economic resilience, given the breadth and richness of concepts associated to it. Based on concepts outlined in Martin and Sunley (2015), Behrens, Boualam, and Martin (2020) distinguish between resilience at the plant level and resilience at industry or regional level. Other recent papers, such as Martin, Mayer, and Mayneris (2017) and Dai et al. (2021), use the term resilience without defining it explicitly, but their quantitative analyses implicitly associate the concept to the responses of firms to aggregate shocks. In this paper, we focus on resilience at the level of individual firms and take a broad view on the concept, understanding it as the ability to cope with the consequences of negative economic shocks.

In order to implement the quantitative analysis included in Section 5, we need operational definitions of resilience. The previous literature quantifying resilience in

regional clusters has used a variety of quantitative measures along the intensive and extensive margins of firm performance.[11] Martin, Mayer, and Mayneris (2017) use the probability of survival and the growth rate of exports conditional on survival. Behrens, Boualam, and Martin (2020) employ two measures to quantify firm-level resilience: the probability that a firm survives and stays within the cluster (indicative of "within" resilience) and the probability that a firm survives but switches to a different economic activity, effectively leaving the cluster (indicative of "between" resilience). To provide comparable results, we follow this literature and define four measures that reflect firm responses to shocks as indicative of our conceptual definition of economic resilience: firm exit, revenue growth, a change in a firm's main economic activity, and the ability of a firm to keep up with local taxes. To the best of our knowledge, the latter measure is novel to the literature.

3 Background

In this Section, we provide some background about the City of Córdoba as a technology cluster and the emergence of the Córdoba Technology Cluster (CTC) initiative. The analysis is mostly based on prior studies documenting the experience of the CTC (Pujol, 2006; Motta, Morero, and Borrastero, 2018), as well as interviews we conducted for this study.

3.1 The City of Córdoba as a Technology Cluster

The City of Córdoba is the second most populous city in Argentina with 1.4 million inhabitants, 3% of the nation's total population. It is the largest urban area in the country (576 square kilometers) and constitutes a continuous metropolitan area of approximately 30 kilometers. The city is a pioneer in technology and software development in Argentina. Historically, Córdoba has been home to many firms in the information technology (IT) services and electronic equipment sectors serving the automotive, aviation, and other manufacturing industries located in Córdoba. Starting in the late 1970s, these firms progressively started incorporating complementary software development activities.[12] New firms specialized in the provision of software services started to emerge during the 1980s and, during the 1990s, the

[11] Delgado and Porter (2021), who look at industries rather than firms, use employment growth as a measure of resilience.

[12] For instance, in 1978, Microsistemas, a spin-off of a local data-processing firm in Córdoba, developed the first Argentine computer to process their data and compete with IBM in the local market.

number of firms grew consistently as the demand for IT services surged with the spread of computers and other digital hardware.[13] According to data from the Ministry of Employment, Labor, and Social Security of Argentina (MTEySS), by 2001 there were 100 firms in IT services sectors[14] located in the Province of Córdoba (6% of all firms in these sectors in Argentina), most of which were located in the City of Córdoba.[15]

With the turn of the century, Córdoba started to attract local affiliates of export-oriented IT multinationals following outsourcing strategies. Motorola was the first to set up a local affiliate in the City of Córdoba in 2001, with an export-oriented software development center servicing the company's hardware, which was not produced in Argentina. According to Pujol (2006), based on interviews with local industry participants, Motorola's presence allowed the city to position itself as a relevant technology cluster not only in Argentina, but also in Latin America. In fact, Motorola was followed by Intel in 2006, Electronic Data Systems-Hewlett Packard and Gameloft in 2007, and Indra in 2008. In a 2007 story, Reuters stated that "the central Argentine province of Córdoba is styling itself as the country's own Silicon Valley, and more than 250 technology firms already call it home" (Grazina, 2007).

Several features made Córdoba an attractive city to establish subsidiaries of export-oriented IT multinationals around the beginning of the 2000s (López, Ramos, and Torre, 2010). First, the devaluation of the peso in 2002 implied a dramatic decrease in local production costs, including labor, electricity, and construction costs. Second, with six universities strong in engineering and computer sciences, and many large-scale, technology-intensive manufacturing firms, Córdoba benefited from a relatively large pool of highly skilled human resources. Argentina is also in a convenient time zone relative to the U.S. and some European countries, which was relevant for exporting software and IT services. Finally, both the provincial and municipal governments offered strong incentives to multinationals who decided to locate in the city. For example, Motorola benefited from a 10-year exemption from municipal taxes, the provincial government agreed to give a subsidy equal to 7.5% of Motorola's wage bill for training purposes, and the municipal government agreed to build two 6,000- square-meter buildings to host the company's activities. Intel benefited from

[13] In Argentina, this coincided with trade liberalization and the appreciation of the peso, which lowered the costs of imported hardware.

[14] The MTEySS classifies these sectors as ISIC Rev. 3.1 groups 722 "Software publishing, consultancy and supply," 723 "Data processing," and 724 "Database activities and online distribution of electronic content."

[15] Although the data do not allow us to identify the location of firms within the province, Pujol (2006) reports that, by 2001, the City of Córdoba was home to 160 firms specialized in IT services and electronics.

a similar arrangement.

3.2 The Emergence of the Córdoba Technology Cluster Initiative

Argentina has at least 32 cluster organizations who identify themselves as "technology," "IT," or "software" cluster organizations, located in 19 out of 24 provinces, as illustrated in Figure 1.[16] Most of these organizations emerged between 2001 and 2010, in line with the growth of the industry in Argentina, and also with the initiation of most of the cluster organizations surveyed by Lindqvist, Ketels, and Sölvell (2013) in more than 30 countries. Interestingly, the most frequent sector among cluster organizations surveyed by Lindqvist, Ketels, and Sölvell (2013) was information technology (14% of all organizations). Although there are cases of public-private initiatives, most initiatives in Argentina are privately led. As of 2017, they comprised around 1,100 firms which employed more than 29,000 workers.

The Córdoba Technology Cluster (CTC) was the first formal private technology cluster initiative in Argentina. It was created in 2001 as a non-profit organization by a group of 10 entrepreneurs from the incipient local technology cluster as a defensive response to the announcement of the establishment of local affiliates of export-oriented IT multinationals, particularly Motorola. Initially, multinationals like Motorola were seen as a threat to local technology firms, not only because they crowded out subsidies and public resources, but more importantly because they offered higher wages and stole away scarce high-skilled workers.

According to interviews with founding members we conducted for this study, the aim of the organization was inspired by the work of Porter (1990) and cluster experiences in the Basque Country, and it focused on establishing coordination and cooperation mechanisms among local firms, strengthening competitiveness, and taking concerted actions to secure a pool of skilled human resources for local firms.[17] This approach gradually changed the view of local entrepreneurs, who realized that, rather than being a threat, multinationals could be strategic partners that could

[16] See for instance the list of members of the SMEs Digital Support Network initiative of the Ministry of Productive Development of Argentina, available at https://www.argentina.gob.ar/produccion/asistencia-digital-para-pymes/integrantes. The ministry labels these cluster initiatives "technology clusters and hubs." Interestingly, it distinguishes them from "business chambers and associations," composed of firms specialized in the same sectors.

[17] One of the CTC's founding members we interviewed, who led the organization at its inception, actually recalls distributing Porter (1990)'s chapters among entrepreneurs in training sessions during the initial meetings of the organization.

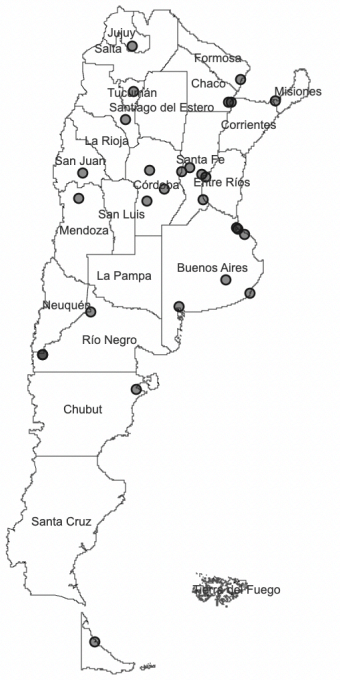

Figure 1: Location of Technology Cluster Initiatives in Argentina

attract new business opportunities, position Córdoba globally, and enlarge the pool of skilled workers by partnering with local universities and other training institutions. In fact, shortly after formally establishing the organization, the CTC, with the support of Intel –which had donated IT equipment to local universities years in advance of opening its local affiliate– brought together the six main universities in Córdoba and formed the Córdoba Technological Institute (CTI). The CTI was one of the first endeavors of the organization and was instrumental in adapting graduate and undergraduate curricula to the needs of the local industry. As the CTC matured, it began to have an increasing influence on the design of public policies aimed at the software and IT services sectors.

4 Membership in the Cluster Initiative and Resilience: Insights from Interviews with Industry Participants

To better understand the mechanisms that could make members of the cluster initiative more resilient, we conducted semi-structured interviews with CTC authorities, member firms, non-member firms, and policy makers. Interviews were structured around questions regarding the aims and objectives of the cluster initiative, the perceived and actual advantages and benefits of belonging to it, and its role in affecting the design and implementation of local and national public policies, among others.[18]

We managed to interview the president and second vice president of the CTC, a founding member and former president of the board, three firms that are active members, and two local firms that do not belong to the initiative. We also conducted interviews with representatives of the Secretariat of Economics and Finance of the City of Córdoba.

In this Section, we describe how the organization works and summarize the main insights derived from our interviews.

Institutional design, governance, and objectives. The CTC is a business-led legal non-profit organization governed by a board of directors, composed of a president, four vice presidents, and nineteen other members, all of which hold positions at member firms (generally as presidents or CEOs). Employed staff amounts to five people, including an operations manager, which is well above the median of two employees documented by Lindqvist, Ketels, and Sölvell (2013). According to CTC authorities, the main objectives of the cluster initiative are augmenting the supply of skilled workers, increasing the internationalization of technology firms, and strengthening ties between actors of the technology value chain, including universities. Some members have also identified affecting public policy as an objective of the organization. The strategy to achieve the CTC goals is to create associative and collaborative initiatives among its members and with other sectors, including the government, other cluster initiatives, and the academic sector.

Membership in the cluster initiative. As is the case in more than 70% of the cluster initiatives surveyed by Lindqvist, Ketels, and Sölvell (2013), CTC membership is formal. Firms who want to become part of the organization need to apply and

[18]Interviews were carried out between July and September of 2021. The Appendix includes the questions that guided the interviews.

be approved by the board, and once approved they must pay a monthly membership fee, which is dependent on firm size.[19] Although eligibility requirements are not explicit, CTC authorities interviewed for this study explained that, when considering potential members, the board validates that firms are located in Córdoba and that they are part of the technology value chain, which they described as including mostly software development and IT consulting, but also complementary industries such as hardware manufacturing and telecommunications. There are no restrictions based on foreign ownership, firm size, or type of organization, so that, for instance, universities (public and private), business chambers, or non-governmental organizations can be part of the cluster organization.

Although membership fees are relatively low compared to average revenues, they may work as a barrier to membership. In fact, CTC authorities mentioned that some firms have terminated their membership arguing they could not afford to pay this fixed cost (e.g., in times of crisis). Another relevant reason identified by firms for not participating in the organization is the perception that the CTC's actions are an excuse for pursuing mainly lobbying activities and/or involvement in local politics. In fact, the minister of science and technology of the province of Córdoba appointed in 2019 was president of the cluster organization board between 2013 and 2015. Even though lobbying activities and investing in political connections may be necessary to shape public policy and contribute to cluster resilience and growth, some firms perceive these efforts as deriving from entrepreneurs' personal ambitions, which discourages their involvement in the organization. In other cases, firms feel that either the political leaning of the board or its strategy are not aligned with their objectives and goals, and hence don't see an interest in becoming members of the organization.

Benefits to members of belonging to the cluster initiative. The CTC offers a variety of benefits to member firms that can contribute to strengthening members' economic resilience along different dimensions. The CTC has agreements with major medical insurance providers and educational institutions, by which members can access discounts or reduced fees for their employees. The organization also organizes training and awareness activities, directly or through collaboration with local universities, in addition to talks and events by experts or industry leaders. Members can also benefit from business rounds with international investors and potential clients, as well as missions abroad to learn about new markets, business opportunities, and trends in technology sectors. Other networking activities include the organization

[19]There are three types of fees: for start-ups or microenterprises, medium firms, and large firms.

of Córdoba Tech Week, an annual event which brings together entrepreneurs, investors, students, and policy makers. Moreover, the CTC staff provides information about new or existing government programs, such as grants programs or promotional regimes, and assists members on how to meet eligibility criteria and prepare required documentation. The latter seems to have been helpful during the 2018 crisis, when the CTC helped some members apply to benefits of the Software Promotional Regime, which reduced social security contributions and corporate income tax. More generally, member firms maintained that belonging to the cluster initiative allows them to access first-hand information and "know what's going on" in the sector.

The CTC operationalizes these benefits through different working parties or commissions, open for every member to participate in according to their interests. Every year, commissions are defined in accordance with an annual strategic plan, together with their specific objectives, actions, and activities to be carried out. Currently, the CTC maintains five commissions:

1. *Markets commission*, in charge of promoting the internationalization of firms and fostering firm growth.

2. *Training commission*, in charge of implementing training activities and working with local universities and educational institutions to adapt their curricula and learning methodologies.

3. *Services commission*, in charge of negotiating and obtaining benefits for members.

4. *Tax commission*, in charge of analyzing tax issues and potential tax benefits or subsidies for the IT sector.

5. *Incubator commission*, in charge of promoting technology start-ups and incubating new projects.

To facilitate the flow of information about benefits and initiatives, the CTC maintains open and agile communication channels, such as mailing lists and WhatsApp groups. According to members and authorities, these channels are used by firms to share experiences (e.g., in selling to foreign markets or dealing with specific suppliers), business or collaboration opportunities, job offers, or personnel and equipment needs. For instance, interviews revealed that, during the COVID-19 pandemic, these channels were useful for firms to inform other members about spare office space available for sharing, workers who were going to be made redundant and could potentially

be hired by other members, or potential clients who needed to develop websites, online stores, or customized software as they adapted their business models in response to the pandemic. In some cases, these communication efforts have resulted in group buying, allowing firms to purchase equipment or services at reduced prices. Some members have also commented that these channels can serve to acquire information about factor markets, such as salary bands, and can allow firms to distinguish aggregate from idiosyncratic shocks.

A natural question regarding members' access to the benefits offered by the cluster initiative is how equal this access is. Put differently, it may be that benefits accrue only to a selected group of members, such as those that participate in the board or larger firms. In fact, CTC authorities and members recognized that there is heterogeneity in participation or involvement in the organization's activities, some of which is related to size. Consistent with this, in interviews, smaller firms did not identify collaboration or cooperation to exploit new business opportunities as a major benefit, which was different for larger firms, who stressed that the organization of business rounds, missions, or the possibility of developing joint projects, were important assets of the organization. For smaller firms, training activities, experience sharing, and networking activities seem to be more accessible and relevant.

Ability of the organization to shape public policy. Although a defining feature of the CTC since its creation has been to avoid participation of government bodies or representatives in the organization, the cluster initiative has built strong links with the public sector and has been able to affect public policy to a great extent. Members of the CTC board also have a seat on boards of public-private organizations and initiatives, such as the Economic Development Agency of the City of Córdoba (ADEC) or the Córdoba Start and Innovate Agency, a provincial public-private agency to promote innovation and entrepreneurship, and the current minister of science and technology was president of the CTC between 2013 and 2015. Current CTC members and authorities see these ties as an advantage of the organization, but recognize that these efforts go beyond the organization boundaries and are intended to benefit the local technology cluster.

Some recent policies that resulted from demands, proposals and close collaboration between the CTC and the public sector to design and implement policies aimed at benefiting firms in the technology cluster include the Program for Labor Insertion in New Technologies and the Knowledge Economy Promotional Regime, implemented by the provincial government in 2021 and 2020, respectively. The first program is an on-the-job training program aimed at training young workers as full-stack developers in firms specialized in software development. It is coordinated by

the CTC together with the ministry of labor, the ministry of science and technology, and the ministry of education. The second is a promotional regime aimed at firms in technology and knowledge-intensive sectors that offers tax breaks and incentives to hire and train workers, which adapts a similar program that existed at the national level. The CTC actively participated in its design, which includes the creation of a public-private advisory board to analyze and propose new initiatives that can promote knowledge-intensive activities in the Province of Córdoba.

Locational advantages. Some cluster initiatives provide members with locational advantages by facilitating common office space, buildings, or facility centers in strategic locations within a region or city. In fact, in 2008 the government of the Province of Córdoba and the CTC initiated a public-private partnership to build a common facility center located near the city airport, aimed at hosting local technology firms. While some members of the CTC decided to locate there, members and authorities that were interviewed coincided in that the project did not work as expected and the location proved to be inconvenient. Moreover, they did not point to advantages of the organization derived from co-location of members. Figure 2 shows the location of CTC members, universities, and government agencies in the City of Córdoba as of 2021. In general, CTC members are located around the city center and the airport, in line with the density of firms in the city. Also, they don't seem to be located particularly close to universities or government agencies.

5 Membership in the Cluster Initiative and Resilience: Evidence from Firm-Level Data

The qualitative evidence presented in the last Section about the benefits offered by the CTC suggests that the cluster initiative could play a key role in fostering resilience among member firms. In this Section, we explore this hypothesis exploiting firm-level panel data to quantify the relationship between belonging to the cluster initiative and economic resilience. We start by describing the data and defining the measures of economic resilience we employ. Then, we describe and discuss the estimation strategy. Finally, we present descriptive statistics and our estimation results.

5.1 Main Data Sets

Our quantitative approach exploits firm-level administrative data from the Secretariat of Economics and Finance of the City of Córdoba. The main data set covers

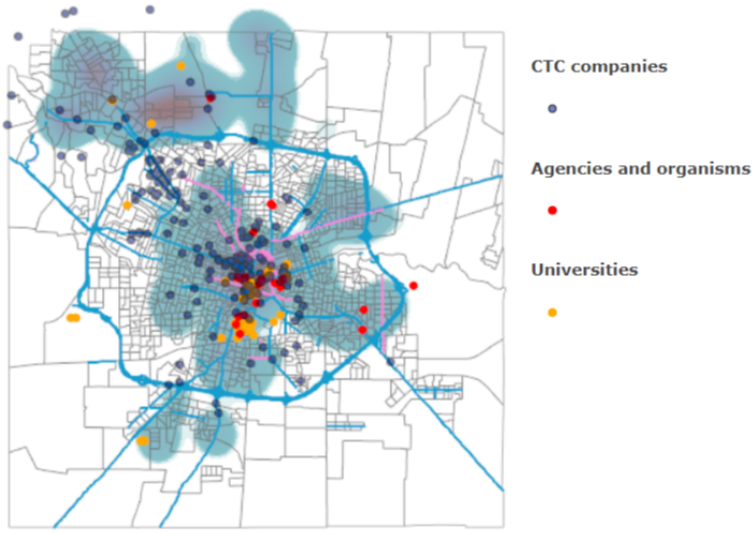

Figure 2: Location of CTC Members, Universities, and Government Agencies, City of Córdoba, 2021

the universe of firms that pay taxes in the City of Córdoba, including information on tax ID, firm name, all registered economic activities declared by the firm, revenues disaggregated for each of the firm's registered economic activities, accrued tax obligations, and tax payments, on a monthly frequency spanning the period from January 2016 to March 2021. Given that firm-level prices are not available, we deflate nominal monthly revenues using the consumer price index for Córdoba.[20]

After cleaning the data and aggregating observations to a quarterly frequency in order to smooth very short-term variations in the data, we are left with 726,326 firm-quarter observations. The number of firms in this main data set varies from 38,442 in the first quarter of 2016 to 20,252 in the first quarter of 2021 (a 47% decrease). To assess the quality of the data, we compare the number of firms in our sample with the number of employer firms reported by the Ministry of Employment, Labor, and Social Security of Argentina (MTEySS), which is based on administrative registers derived from sworn statements that employers must present by law each month

[20]Córdoba's CPI is published monthly by the Province of Córdoba's General Directorate of Statistics and Census. It is representative of average consumption by urban households in the City of Córdoba. A producer price index is not available.

to Argentina's Federal Income Administration (AFIP).[21] For the City of Córdoba, MTEySS reports 32,369 firms for 2016 and 31,577 for 2019, compared to 42,343 and 39,485, respectively, in our sample. Note that our sample includes non-employer (one-person) firms, and hence we should expect our sample to include more firms. From this main data set, we select relevant sub-samples to estimate our econometric model, which are described in the next Section.

To identify members of the cluster organization, we rely on the CTC's member records. As explained in Section 5.3, in order to minimize potential endogeneity concerns, we fix membership in the cluster organization at the beginning of our sample period. Specifically, we have access to the list of all members' names as of October 2016 (the closest period to the first quarter of 2016 that we have access to) and match it with our data base. Out of 162 listed members, we are able to recover tax IDs for 150 members.[22] Of these, 112 could be matched to our main data set and 105 were present in the first quarter of 2016 (65% of listed members).

The variables included in the main data set do not allow us to construct a measure of productivity or efficiency. Therefore, besides the information on firm revenues and the number of activities in which firms are active, we complement the data with other firm-level data that should be correlated with productivity. First, we determine firm export status based on information from ProCórdoba, the Province of Córdoba's trade and investment promotion agency. Then, we collect information on firm participation in national programs targeted to support firms in software and technology sectors, such as the Software Sector Promotional Regime (SPR) and grant programs from the Argentine National Agency for Promoting Research, Technological Development, and Innovation.[23]

5.2 Measures of Economic Resilience

We use several measures to quantify the concept of economic resilience. First, similar to Martin, Mayer, and Mayneris (2017), we use the probability of firm exit and the annual growth rate of firm revenue. We classify a firm as having exited the market in a given quarter if it is the last time we observe the firm in our data set.[24] Second,

[21] The data are available at https://www.trabajo.gob.ar/estadisticas/oede/estadisticasregionales.asp.

[22] In Argentina, firms sometimes operate under a different, commercial name than the one registered with tax registries, which can include the owner's personal name.

[23] Beneficiaries of the SPR are published and publicly available in Argentina's Official Gazette. Beneficiaries of grant programs were obtained from the agency's website.

[24] In our sample, some firms either stop reporting or report zero revenues for some periods, then reappear later with positive revenues. We interpret these instances as temporary inactivity and do not classify them as exits.

following Behrens, Boualam, and Martin (2020), we compute the probability that a firm switched its main economic activity to an activity outside the regional cluster between two consecutive quarters. We define the main activity of a firm in a given period as the activity with the highest share of revenues in that period. Finally, we use an additional measure of resilience and examine whether firms were able to fully meet their tax obligations in every period. That is, we compare accrued taxes with effective tax payments in every period and tag those firm-period observations in which tax payments were less than accrued taxes.[25]

5.3 Empirical Model and Estimation Strategy

One of the aims of this paper is to quantify the relationship between belonging to the cluster initiative and economic resilience to shocks. To do this, we specify the following linear model for the determinants of economic resilience:

$$y_{ijt} = \beta_0 + \beta_1 CTC_i + \beta_2 CTC_i \times \text{Crisis}_t + \boldsymbol{\beta}_3' \mathbf{X}_{it} + I_{jt} + \epsilon_{ijt}, \tag{2}$$

where y_{ijt} is a measure of economic resilience for firm i in industry j in period t, CTC_i is a dummy variable equal to 1 if firm i belongs to the cluster initiative and 0 otherwise, Crisis_t is an indicator variable equal to 1 if period t coincides with a crisis episode.

As discussed in the previous subsection, we employ four measures related to economic resilience (or lack of it): firm exit, changes in the firm's main economic activity to non-cluster activities, annual revenue growth, and tax debt (i.e., paying less than accrued taxes during period t). Moreover, we include sector-year fixed effects (captured by I_{jt}) to absorb common shocks, where sector is a 2-digit aggregate. The error term ϵ_{ijt} captures unobserved shocks at the firm level that affect resilience.

To control for firm characteristics that could affect resilience beyond membership in the cluster organization, we include a vector of time-varying firm-level controls $\mathbf{X}_{it}$. These include (log) revenues and the number of activities with positive revenues ("firm scope"). Additionally, we include time-invariant characteristics: indicator variables for whether the firm benefited from two national public programs targeting software and technology firms sometime before our sample period, and an exporting status variable indicating whether the firm exported during our sample period.[26] Revenues and firm scope can capture productivity shocks, as well as scale

[25] According to the City of Córdoba's tax code, industry, commerce, and services firms pay a fixed tax rate out of total revenues, which can vary at the 8-digit level. Tax rates did not change over the period we study.

[26] Unfortunately, we do not have access to exporting status per period.

effects that could make firms more resilient. Exporting status should account for time-invariant productivity differences across firms, as exporters tend to be more productive than non-exporters. Finally, participation in national programs, apart from capturing firms' ability to access monetary transfers or tax exemptions from the government, which can directly affect resilience, should also be correlated with firm productivity, since, in order to participate in these programs, firms must meet eligibility criteria related to either expenditures in research and development (R&D), innovation, quality and technical certifications, or exporting.[27]

The coefficients of interest are β_1 and and β_2. Coefficient β_1 measures the extent to which belonging to the CTC is associated to our measures of economic resilience. If belonging to the CTC is associated to firms being more resilient, β_1 should be negative for all our resilience measures, except for revenue growth, for which it should be positive. Coefficient β_2 captures the association between CTC membership and resilience during crisis periods.

We estimate different versions of model (2) using OLS below. In order to minimize potential endogeneity issues, our estimating sample is restricted to firms that were present at the beginning of our sample period (first quarter of 2016), excluding firms that entered (and potentially exited) after that period. This could include firms that were active in 2016 but joined the CTC *after* 2016, which could bias our coefficients of interest downward, since firms labeled as not belonging to the CTC but who actually joined the organization at some point could benefit from any mechanism that makes CTC firms more resilient. For this reason, we exclude from the estimating sample firms that were members of the CTC in 2021 but not in 2016. Note that, since the CTC_i indicator is determined by CTC membership in 2016, we do not aim to do a before/after analysis of joining a cluster initiative and we do not claim to identify β_1 as the causal effect of joining the CTC on economic resilience. Finally, when estimating model (2), standard errors are clustered at the 2-digit sector level.

5.4 Descriptive Statistics

Before presenting our results, we describe some features of our estimating sample. Our baseline estimating sample is restricted to firms in the regional technology cluster (which by definition includes CTC members), as defined in Section 2. That is, we compare CTC firms to firms in the same regional cluster that are not members of the

[27]For instance, in order to apply to the SPR, firms must meet at least one of the following conditions during the first year, and at least three during the second year: (i) show R&D expenditures above 3% of total revenues, (ii) have a quality or process certification, or (iii) export at least 8% of total revenues.

organization. Table 3 shows the number of firms in the regional technology cluster and in the cluster organization in the first quarter of every year. The number of firms in the technology cluster varies from 2,665 firms in the first quarter of 2016 to 1,441 in the first quarter of 2021. There is a clear downward trend in the number of firms, with significant drops especially in the first quarter of 2018 (-11%), reflecting the impact of the macroeconomic crisis, and in the first quarter of 2020 (-23.8%), amidst the outbreak of the first wave of the COVID-19 pandemic. Compared to the total number of registered firms in the City of Córdoba, the regional cluster experienced a larger decline during the macroeconomic crisis than during the COVID-19 crisis. In turn, the number of firms in the cluster organization decreases from 105 to 95 during the sample period, and the decline is more gradual than in the case of non-members.

Table 3: Sample Selection and Size for Selected Quarters, 2016–2021.

	Number of firms			Annual % change		
Quarter	All firms	Tech cluster firms	CTC members	All firms	Tech cluster firms	CTC members
2016q1	38,443	2,665	105	-	-	-
2017q1	40,091	2,555	105	4.29	-4.13	0.00
2018q1	37,323	2,275	105	-6.90	-10.96	0.00
2019q1	37,275	2,111	104	-0.13	-7.21	-0.95
2020q1	23,480	1,608	98	-37.01	-23.83	-5.77
2021q1	20,253	1,441	95	-13.74	-10.39	-3.06

Notes: This table presents the total number of firms in tax records data, the number of firms that belong to the regional technology cluster, and the number of firms that belong to the CTC initiative, and their respective annual percentage changes. Data are restricted to those firms that were active in the first quarter of 2016 (there is no entry of new firms) and firms that joined the CTC after 2016 are excluded.

Table 4 shows that firms that belong to the cluster organization were larger (as measured by total revenues, in column 1), were active in more economic activities (column 2), and were more likely to participate in national support programs (FONSOFT and the SPR, in columns 3 and 4) than non-member firms. Figure 3 complements these observations by showing the distribution of log revenues for CTC and non-CTC firms in the first quarter of 2016.[28] While there is substantial

[28]The distributions are very similar irrespective of the year we consider. Since some firms report zero revenues in some periods, we add 1 before taking logs. Revenues are expressed in thousand Argentine pesos.

overlap between both groups of firms, the observable characteristics of CTC firms suggest there could be selection effects by which larger, potentially more resilient firms self-select (or are selected) to become members of the cluster initiative. Moreover, since belonging to the cluster organization entails paying per-period fixed costs, it is plausible that more productive firms are more likely to become members. For these reasons, in presenting our regression results below, we will be careful not to draw causal interpretations from the association between our measures of economic resilience and CTC membership.

Table 4: Descriptive Statistics

	(1) Revenues	(2) Firm scope	(3) Exporter	(4) FONSOFT	(5) SPR^{past}
CTC	1.957***	0.074***	0.376***	0.475***	0.201***
	(0.061)	(0.018)	(0.003)	(0.003)	(0.002)
Observations	45,151	45,151	45,151	45,151	45,151

Note: Standard errors in parentheses. *, **, and *** indicate significance at the 0.10, 0.05, and 0.01 levels, respectively.
Source: authors based on tax registries.

5.5 Results

We first present the results of estimating model (2) without controls ($\beta_2 = 0$, $\boldsymbol{\beta}_3 = \mathbf{0}$) nor fixed effects in Table 5. Column (1) shows results for firm exit; that is, y_{ijt} equals 1 if firm i exited the market in quarter t and 0 otherwise. The estimated coefficient of CTC_i indicates that the probability that a firm in the cluster organization exited the market was lower by 2.4 percentage points. The coefficient in column (2) shows that CTC firms were also less likely to switch their main economic activity to a sector outside the local technology cluster between $t-1$ and t. In column (3), we examine whether firms that belonged to the cluster organization showed higher revenue growth than non-CTC firms. To avoid noise and reversion to the mean, we calculate revenue growth as the year-on-year normalized growth rate of quarterly revenues, $y_{ijt} = \frac{r_{ijt} - r_{ijt-4}}{(1/2)(r_{ijt} + r_{ijt-4})}$, where r_{ijt} denote revenues.[29] Indeed, revenue growth is both statistically and economically significantly higher among CTC firms. The

[29]See Davis and Haltiwanger (1992). This measure is monotonically correlated with the standard growth rate measure, and both are approximately equal for relatively small values.

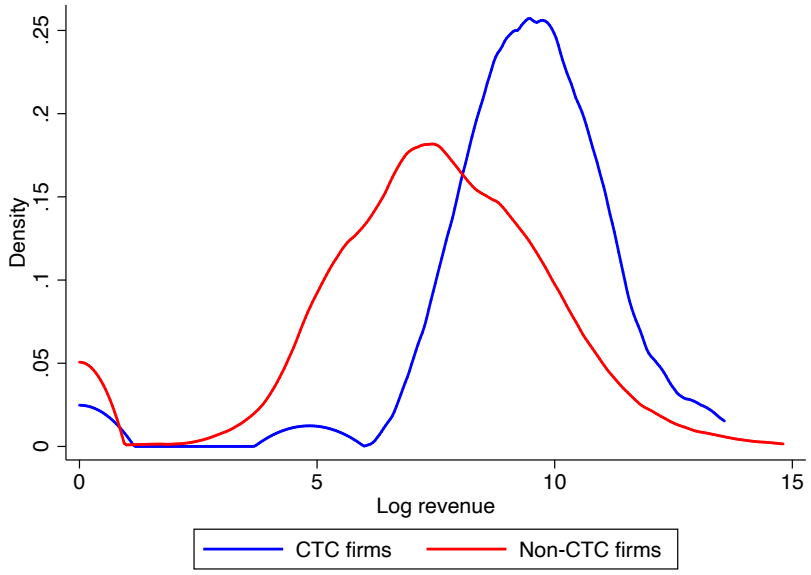

Figure 3: Kernel Densities of Log Real Revenues for CTC and Non-CTC firms, First Quarter of 2016

Note: This figure plots non-parametric estimates of the densities of the log of firm real revenues for CTC and non-CTC firms, using data for the first quarter of 2016.

normalized growth rate for these firms was higher by 11.9 percentage points than for non-CTC firms. Finally, in column (4) we look at firm tax debt; that is, y_{ijt} equals 1 if firm i could not pay accrued taxes in period t and 0 otherwise. The associated coefficient shows that CTC firms were less likely to incur tax debt than non-CTC firms. Taken together, these results suggest that firms in the cluster organization were more resilient along all the dimensions we consider than firms that did not belong to it, even when all firms belong to the same local cluster and were localized close to each other in the same metropolitan area.

As discussed above, the evidence presented in Table 4, together with the institutional features of the CTC (i.e., firms must apply for membership and, conditional on being accepted, must pay a per-period fixed membership fee), raises the concern that firms may have self-selected into the organization based on productivity or performance (e.g., as in a standard Melitz (2003)–type model). For instance, Albornoz, Cabrales, and Hauk (2019) write a model in which more productive firms invest more in socializing, networking, and acquiring information, which in turn increases their productivity. Section 4 presents qualitative evidence that large firms do in fact

Table 5: Resilience of CTC Firms (linear model, no controls)

	(1) Firm exit	(2) Sector switch	(3) Revenue growth	(4) Tax debt
CTC	-0.024***	-0.014*	0.119***	-0.104***
	(0.004)	(0.006)	(0.023)	(0.015)
Observations	45,151	45,151	33,567	45,151
Industry-year FE	No	No	No	No

Note: Standard errors clustered by industry in parentheses. $*$, $**$, $***$ indicate significance at the 0.10, 0.05, and 0.01 levels, respectively.

participate in the organization more than others. There could also be sector-specific characteristics or shocks that could have made some firms more resilient than others, irrespective of membership in the cluster organization.

To account for these differences, we estimate a specification of model (2) that includes firm-level controls and industry-year fixed effects, not yet including an interaction with crises episodes (i.e., $\beta_2 = 0$). Results are presented in Table 6. Conditioning on firm characteristics and industry-year shocks significantly changes the estimates of our coefficient of interest, β_1. Under this specification, results show that CTC members are indistinguishable from non-members with respect to firm exit or switching economic activity, and actually experience *lower* revenue growth than non-members. We still find that CTC firms are more likely to honor their tax obligations, but the coefficient is significantly lower and is less precisely estimated than in the specification without controls.

Results in Table 6 indicate that, besides industry-year fixed effects, most of the positive relationship of CTC membership with resilience presented in Table 5 is absorbed by firm size (as measured by revenues). Larger firms tend to be more resilient, as they are less likely to exit (although by a low margin), show higher revenue growth, and are more likely to fully meet their tax obligations. Firm size does not appear to affect a firm's probability of changing its main economic activity. Of the program participation controls, only having benefited from the SPR has a statistically significant relationship with resilience, although the signs of some of the coefficients are different from what we would expect. While firms that benefited from the SPR before our sample period are less likely to incur in tax debt, they are *more* likely to exit and show *lower* revenue growth. Finally, firm scope does not show a relationship statistically different from 0, except with respect to revenue growth, but with an opposite sign than expected. Firms active in more economic activities

Table 6: Resilience of CTC Firms (linear model, with controls)

	(1) Firm exit	(2) Sector switch	(3) Revenue growth	(4) Tax debt
CTC	0.000	-0.004	-0.116*	-0.067*
	(0.007)	(0.003)	(0.045)	(0.032)
Revenues	-0.010***	0.000	0.145***	-0.022***
	(0.001)	(0.000)	(0.004)	(0.002)
Firm scope	-0.001	-0.002	-0.021	-0.003
	(0.001)	(0.002)	(0.011)	(0.002)
Exporter	-0.005**	0.002	-0.098**	0.018
	(0.002)	(0.001)	(0.029)	(0.024)
FONSOFT	0.002	-0.003	0.014	0.038
	(0.002)	(0.004)	(0.023)	(0.020)
SPR^{past}	0.021***	0.002	-0.230***	-0.046***
	(0.004)	(0.002)	(0.038)	(0.005)
Observations	45,151	45,151	33,567	45,151
Industry-year FE	Yes	Yes	Yes	Yes

Note: Standard errors clustered by industry in parentheses. $*$, $**$, $***$ indicate significance at the 0.10, 0.05, and 0.01 levels, respectively.

experience lower revenue growth during our sample period.

We close this section examining the resilience of firms in the cluster organization during the two aggregate shocks covered by our sample period: the exchange-rate crisis that unfolded between the first and third quarters of 2018, and the first wave of the COVID-19 pandemic, which hit Argentina during the first and second quarters of 2020. To this end, we estimate model (2) under its full specification. We consider three alternatives for the Crisis_t indicator variable in Table 7: (i) it is equal to 1 if t falls in any of the two crisis periods and 0 otherwise (columns 1, 4, 7, and 10); (ii) it is equal to 1 if t corresponds to a quarter during the 2018 crisis and 0 otherwise (columns 2, 5, 8, and 11); and (iii) it is equal to 1 if t corresponds to a quarter during the COVID-19 crisis and 0 otherwise (columns 3, 6, 9, and 12).

The motivation behind examining the two crisis periods separately is that the nature of each of these shocks was different, with potential implications for firm outcomes. The 2018 macro crisis was characterized by a run against the peso and

an increase in interest rates to contain it, which in principle affected all cluster firms equally. The COVID-19 crisis, instead, may have favored cluster firms, which were specialized in the provision of software services and digital solutions or manufacturing of electronic equipment, and in particular CTC firms, which may have had access to a richer information set about business opportunities, including by providing the local government with applications or solutions to monitor the sanitary crisis.

The results in Table 7 show that, in general, and except with respect to their ability to meet tax obligations during the COVID-19 crisis, CTC firms do not appear to have been more resilient than non-CTC firms during the crisis periods we consider. When we analyze the probabilities of exiting or switching sectors, the coefficients associated to the interactions between CTC membership and a crisis period are not statistically different from 0. In the case of revenue growth, while the coefficient associated to the 2018 crisis is positive, suggesting CTC firms were somewhat more resilient than non-members during that period, it is imprecisely estimated. Finally, CTC firms do appear to have been more able than non-members to fully meet tax payments during the COVID-19 crisis. However, the 2018 crisis seems to have hit CTC firms harder in this respect, increasing the probability that they incurred tax debt.

Table 7: Resilience of CTC Firms During Crisis Periods (linear model, with controls)

	Firm exit			Sector switch			Revenue growth			Tax debt		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
CTC	0.001	0.000	0.001	-0.004	-0.004	-0.004	-0.136**	-0.135**	-0.128**	-0.064*	-0.062	-0.070*
	(0.008)	(0.008)	(0.009)	(0.003)	(0.003)	(0.003)	(0.045)	(0.044)	(0.043)	(0.031)	(0.031)	(0.031)
CTC × Crisis period	-0.003			-0.001			0.066			-0.015		
	(0.010)			(0.001)			(0.048)			(0.010)		
CTC × 2018 crisis		0.000			-0.000			0.099			0.043**	
		(0.010)			(0.001)			(0.067)			(0.015)	
CTC × Covid-19			-0.008			-0.003			0.020			-0.096***
			(0.010)			(0.002)			(0.044)			(0.016)
Observations	45,151	41,996	38,424	45,151	41,996	38,424	33,567	30,546	27,050	45,151	41,996	38,424
Industry-year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm-level controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: Standard errors clustered by industry in parentheses. $*$, $**$, $***$ indicate significance at the 0.10, 0.05, and 0.01 levels, respectively.

5.6 Robustness Checks

A concern regarding our previous estimates is that the definition of technology cluster we consider to construct our control group is too broad. Given that the CTC mostly targets firms specialized in software development and IT consulting services, we may be comparing their performance to those of firms that are members of other sectoral or cluster organizations or receive benefits from other government programs. This would bias our estimates downwards. Therefore, as a robustness check, we re-run our regressions considering a more restricted group of industries which includes software development and IT consulting industries only. Tables 8 and 9 show that our results are practically unchanged when we consider a sub-cluster within our regional technology cluster.

Table 8: Resilience of CTC firms, software and IT consulting (linear model, with controls)

	(1) Firm exit	(2) Sector switch	(3) Revenue growth	(4) Tax debt
CTC	-0.007	-0.010	-0.040	-0.109***
	(0.007)	(0.012)	(0.023)	(0.020)
Revenues	-0.009***	0.001	0.148***	-0.019***
	(0.000)	(0.002)	(0.007)	(0.001)
Firm scope	0.004**	-0.012	0.026	0.005
	(0.001)	(0.014)	(0.014)	(0.004)
Exporter	-0.003	-0.001	-0.124***	0.023
	(0.002)	(0.001)	(0.027)	(0.030)
FONSOFT	0.001	-0.002	0.004	0.052***
	(0.001)	(0.001)	(0.027)	(0.013)
SPR^{past}	0.021***	0.002	-0.280***	-0.042***
	(0.006)	(0.003)	(0.027)	(0.004)
Observations	22,098	22,098	16,363	22,098
Industry-year FE	Yes	Yes	Yes	Yes

Note: Standard errors clustered by industry in parentheses. $*$, $**$, $***$ indicate significance at the 0.10, 0.05, and 0.01 levels, respectively.
Source: authors based on tax registries.

Table 9: Resilience of CTC Firms During Crisis Periods, Software and IT Consulting (linear model, with controls)

	Firm exit			Sector switch			Revenue growth			Tax debt		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
CTC	-0.005	-0.006	-0.005	-0.009	-0.009	-0.009	-0.052***	-0.055***	-0.049***	-0.105***	-0.104***	-0.112***
	(0.009)	(0.009)	(0.010)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.008)	(0.021)	(0.020)	(0.019)
CTC × Crisis period	-0.006			-0.004			0.041			-0.016*		
	(0.010)			(0.005)			(0.048)			(0.007)		
CTC × 2018 crisis		-0.003			-0.003			0.041			0.039**	
		(0.009)			(0.004)			(0.064)			(0.011)	
CTC × Covid-19			-0.009			-0.006			0.040			-0.088***
			(0.012)			(0.008)			(0.030)			(0.012)
Observations	22,098	20,503	18,772	22,098	20,503	18,772	16,363	14,853	13,176	22,098	20,503	18,772
Industry-year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm-level controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: Standard errors clustered by industry in parentheses. ∗, ∗∗, ∗ ∗ ∗ indicate significance at the 0.10, 0.05, and 0.01 levels, respectively.

6 Conclusion

This paper contributes to the understanding of how cluster initiatives shape firm resilience. We study the Córdoba Technology Cluster (CTC), a cluster initiative in the City of Córdoba, Argentina, during the period between January, 2016 and March, 2021, which covers two recent crises: the macroeconomic crisis that unfolded in Argentina during the first half of 2018, and the first wave of the COVID-19 pandemic during the first half of 2020. We find that the cluster initiative provides its members with an environment that can foster higher resilience during crisis compared to non-member firms, although members do not explicitly identify fostering resilience as a mandate of the organization. Despite this qualitative finding, we cannot find quantitative evidence of a positive relationship between membership in the cluster initiative and firm resilience. Member firms do not show higher survival rates, higher revenue growth, nor a higher probability of staying in their core industry than non-members within the same regional cluster. They are, however, more likely to keep up with municipal taxes.

We document evidence suggesting the cluster organization can generate spillovers among non-member firms. First, there are initiatives which are open to non-members, such as conferences and training events. Second, the CTC influences the design and implementation of government policies targeting the sector, which can benefit firms that meet eligibility criteria independently of CTC membership status. If these initiatives contribute positively to firm resilience, it would bias our results towards finding a weaker relationship between belonging to the cluster initiative and developing economic resilience. Data limitations prevent us from controlling for the presence of spillovers in this setting. We see the quantification of spillovers among cluster and non-cluster firms as a fruitful avenue for future research, which could improve our knowledge about how cluster initiatives affect firm outcomes and, in turn, inform evidence-based cluster development policies.

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Appendix

Questions included in interviews with CTC authorities, CTC firms, and other industry participants

1. Regarding the motivation, aim and objectives behind the formation of the cluster initiative:

    - What was the motivation for establishing the CTC?
    - What were the objectives of the CTC? How have they changed since its creation?
    - To what extent has the CTC achieved its objectives?
    - What were the main accomplishments of the CTC (initiatives, networks, possibility to affect or shape public policy)?
    - What were the most important shortcomings of the CTC?
    - What is the main contribution of the CTC to the economy of Córdoba and the ICT sector as a whole?

2. Regarding advantages for firms of being members of the cluster organization:

    - What are the main advantages of belonging to the CTC?
    - What services or benefits does the CTC provide to member firms?
    - What services should the CTC provide that are currently not provided?
    - How do member firms perceive and/or relate to other members of the cluster organization?
    - What prevents other firms from joining the CTC?

3. Regarding the role of the cluster initiative in shaping public policies:

    - To what extent did the CTC contribute to the design and implementation of public policies benefiting the regional ICT cluster in Córdoba? Mention specific examples or initiatives.
    - Has the CTC influenced national policies beyond Córdoba?
    - (To member firms) How has your firm benefited from specific public policies due to CTC membership? (information about grants and/or support to apply, access to promotional tax regimes, access to training programs, etc.)

- Has the CTC provided benefits or services related to the COVID-19 pandemic?

4. Regarding the perception and features of Córdoba as a regional cluster:

   - To what extent do you perceive the City of Córdoba as regional cluster?
   - Are there regional or national initiatives to strengthen links between firms and/or institutions beyond the City of Córdoba? If there are, who tends to lead these (firms, the CTC, government agencies)?

5. For firms that are not members of the CTC:

   - Do you perceive your firm as belonging to a regional cluster in Córdoba?
   - Do you know of the existence of the CTC?
   - Have you ever tried to become a member? If yes, why aren't you a member? If not, why?
   - What benefits do you think the CTC provides to its members?
   - What benefits do you think the CTC provides to firms and other organizations related to your sector in the City of Córdoba?