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Straining but not thriving: understanding network dynamics in underperforming industrial clusters

Elisa Giuliani[*,†], *Pierre-Alexandre Balland*[**] *and Andrés Matta*[***]

[*]Dipartimento di Economia e Management, University of Pisa, Via Ridolfi 10, 56124 Pisa, Italy
[**]Department of Economic Geography—Urban and Regional Research Centre Utrecht (URU), Utrecht University, Heidelberglaan 2, 3508 TC Utrecht, The Netherlands
[***]Universidad Nacional de Córdoba, Facultad de Ciencias Económicas, Av. Valparaíso S/N, Ciudad Universitaria, X5000HRV Córdoba, Argentina
[†]Correspondence to: elisa.giuliani@unipi.it

Abstract

We investigate the micro-connectivity drivers of network change in an underperforming industrial cluster in Argentina. Our analysis is based on data collected in two consecutive surveys, conducted in 2005 and 2012, of entrepreneurs in the electronics cluster in Córdoba. We find that social and institutional factors influence micro-connectivity choices at the local level, while firms that are more open to non-local knowledge have the tendency to behave like external stars, potentially limiting the flow of non-locally generated knowledge into the cluster network as it grows. We interpret these results using the intuitions from strain theory and suggest that strain may engender an 'everyone for themselves' mentality in the most open cluster firms as they seek to escape from a condition of underperformance. We posit, also, that local social and institutional ties are relevant for most cluster firms to survive, but are not sufficient for the cluster to thrive.

Keywords: Underperforming industrial clusters, local knowledge network, network dynamics, strain theory, social network analysis (SNA), stochastic actor-oriented models (SAOM) of network change, Argentina
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1. Introduction

Most contemporary accounts of industrial clusters[1] discuss successful cases and investigate the reasons for their firms' superior international competitiveness, innovativeness and performance (see among others, Martin and Sunley, 2003; Broekel and Boschma, 2012; Ciravegna, 2014; Delgado et al., 2014; Ter Wal, 2014; Breznitz and Buciuni, 2015; Menzel et al., 2017). The focus on successful clusters, arguably, is due to their economic prominence and the relevance of the lessons derived from their analysis for scholars and policy makers. In contrast, underperforming clusters, defined broadly as industry clusters whose firms' average performance,

1 Among the numerous definitions that have been proposed for the concept, we follow earlier research and define industrial clusters as geographical agglomerations of firms operating in the same or interconnected industries (see Giuliani, 2005).

however measured (e.g., in terms of innovative output, product success or export growth, etc.), are poor and exhibit considerable backwardness compared with the international frontier, have generally received less scholarly attention (exceptions include Schmitz, 1999; Visser, 1999; Kamath and Cowan, 2015). The result is that our knowledge about such cases is somewhat limited.

Most would agree however that many of the world's industry clusters are not flourishing industrial sites, but are rather inferior areas, which survive, but do not thrive, and whose firms, especially if they are located in developing countries, struggle to compete even in the less demanding national market place (Yoshino, 2011; Ali et al., 2016). In these contexts, 'self-employment' often represents a survival activity for local people (Altenburg and Meyer-Stamer, 1999) and, often, clustered producers do not maintain cooperative linkages beyond local borders with the result that the growth and innovative capacity of this kind of clusters remains limited (Visser, 1999).

One area where our understanding of underperforming clusters is limited is related to the characteristics and dynamics of their local knowledge networks. We focus on these networks in this paper since the extant research identifies them as a fundamental channel for the diffusion of innovation-related knowledge and the sharing of experience and tacit knowledge among employees and entrepreneurs, which, eventually, breed success and promote economic growth (see among many others, Owen-Smith and Powell, 2004; Smith-Doerr and Powell, 2005; Li et al., 2012; Balland et al., 2016). Also, local networks are the conduits through which externally generated knowledge is diffused to local actors and, therefore, they are vital components of the cluster's local-global nexus (Coe et al., 2002, 2008; Bathelt et al., 2004; Wolfe and Gertler, 2004; Coe and Yeung, 2015).

Previous network research in economic geography has identified network structures that connect entrepreneurs to one another and yield better outcomes than others. These studies examine the underpinning micro-social behaviours and choices that lead to certain network structures rather than others, in order to theorize about how networks explain economic performance (Glückler, 2007, 2013; Ter Wal and Boschma, 2009; Crespo et al., 2014, 2017; Molina-Morales et al., 2015). Against this background, very little scholarly research has investigated the structure of local networks in underperforming clusters. Some narratives report these networks to be disconnected or fragile (McCormick, 1997; Altenburg and Meyer-Stamer, 1999; Bell and Albu, 1999; Giuliani, 2005), due to the absence of trustful relationships or poor levels of professionalism among local entrepreneurs, who enact opportunistic or predatory behaviours in a bid to survive (UNIDO, 2004). From this perspective, lack of or fragility of local networks is seen as condemning these areas to underperformance and poverty, which has been the motivation for the development of pro-networking policies to resolve such coordination failures (see, e.g., Maffioli et al., 2016).

More importantly, because, over time, these structures may be subject to change and recombination, especially in a developing country context where firms often are affected by turbulent macro-economic environments and policy changes (Li et al., 2012), we need to examine how these networks change. What micro-structural choices do economic actors make in deciding with whom to form a tie? How powerful are these micro-choices for shaping the network structure and what micro-choices perhaps ease or are detrimental to the cluster's development trajectory?

Since we know little about how local networks evolve in developing country underperforming clusters, this investigation is timely. Also, an understanding of underperforming clusters is likely to be relevant to the study of advanced country industry clusters, where the financial crisis has led to declines in once prosperous industrial areas (e.g., De Propris and Lazzeretti, 2009; Fingleton et al., 2012; Martin et al., 2013; Crespo et al., 2014; Østergaard and Park, 2015). In the context of theory, these questions are pertinent because they help to refine existing theories about the functioning and evolution of networks in industrial clusters and, eventually, to understand their role in shaping their development (Glückler, 2007, 2013; Giuliani, 2013; Balland et al., 2016). In the context of policy, the answers to these questions could help to improve the design of cluster development initiatives (Maffioli et al., 2016).

To address these neglected issues, we investigate the structural properties of a local knowledge network in an underperforming electronics cluster in Argentina and study its dynamics over time, using social network analysis (SNA) and stochastic actor-oriented models (SAOM) of network change. We observed the cluster over the period 2005–2012 via two periods of field work and collection of original data using a structured questionnaire administered to local entrepreneurs, which was followed by a focus group.

Our theorizing about the changes in underperforming clusters' local knowledge networks is inspired by strain theory (Merton, 1938; Agnew, 1992, 2001), which was developed originally to understand the 'socio-cultural sources of deviate behaviour' (Merton, 1938, 627). Strain theory has been employed widely to explain criminality; in the present research, it is used to explain the micro-connectivity choices of entrepreneurs in the context of cluster underperformance. Our theory development is based on the assumption that entrepreneurs operating in underperforming clusters suffer from objective strain (Agnew, 1992), that is, they dislike their condition and will enact adaptive behaviours to alleviate the associated strain or negative emotions. Our interest is not in deviant conduct *per se*, but in the potential antisocial repercussions of strain on connectivity choices. In this vein, we develop a conceptual framework, in which strain is connected to different types of drivers—social, institutional and agentic—of network change.

In our work, the social drivers of network change include both well-known network-specific mechanisms of network growth, such as transitivity (Lincoln et al., 1992; Walker et al., 1997; Fehr and Gachter, 2000) and friendship (Lincoln and Miller, 1979; Ingram and Roberts, 2000; Gibbons, 2004; Westphal et al., 2006). By institutional drivers, we refer to normative pressures to form new ties (DiMaggio and Powell, 1983; McDermott et al., 2009; Perez-Aleman, 2011), which, in the context of this paper, are operationalized as pressure from firms' board membership in the local business association and pressure from firms' participation in a local cluster development policy. Finally, we consider agentic drivers as related to the firm's inherent qualities, particularly firm-level innovation and openness to non-local sources of knowledge (gatekeeper versus external stars effect) (Baum and Mezias, 1992; Burt, 1992; Ahuja et al., 2012).

Our evidence shows, first, that this cluster is characterized by a local core–periphery structure, hence, the way knowledge ties are distributed is not excessively fragmented, but is similar in structure to that of many other, more successful, contexts (Cattani and Ferriani, 2008; Giuliani, 2013). Second, when we look at the network dynamics we find support for some of our theoretical expectations, but not others. We discuss our results in light of our conceptual framework and with a view to improving the theoretical connection between networks and clusters.

The paper is organized as follows. Section 2 develops the conceptual framework; Section 3 describes the research context; Section 4 describes the methodology; and Section 5 presents the results. Section 6 discusses the results and Section 7 concludes the paper.

2. Networks and their dynamics in clusters

2.1. On network structures

The way networks are structured—that is, the way the ties between different actors in the network are distributed—is considered to influence the deployment of resources and the coordination of the different actors populating the cluster and other types of industrial organizations (Owen-Smith and Powell, 2004; Schilling and Phelps, 2007; Balland et al., 2013a, b; Ter Wal, 2014). Previous research suggests that different network structures provide advantages and some disadvantages to their members. For instance, dense and cliquish network structures, in which most actors are tightly connected to each other, ensure a cooperative environment, where levels of social monitoring, trust and resource-sharing can be expected to be high (Coleman, 1988; Perez-Aleman, 2011). In contrast, hierarchically structured networks, such as scale-free networks, are less flat and are dominated by a few actors who act as hubs and have outstanding numbers of connections, while the majority of actors are poorly connected (Barabási and Albert, 1999)—a case in point is the 'hub-and-spoke' cluster typology discussed by Markusen (1996) among others. This network structure has the power to distribute resources and knowledge in very uneven and polarized ways, but its advantage is that it allows coordination and control by one or a few relevant actors.

Other intermediate network structures are also possible. Some real-world networks are characterized by a core–periphery structure, that is, by a densely connected core (a clique-like subgroup) and a set of 'hangers-on' (e.g., the periphery), which are loosely connected to the core and very loosely inter-connected among themselves (Borgatti and Everett, 1999; Giuliani and Bell, 2005; Cattani and Ferriani, 2008; Balland et al., 2013b). Core–periphery structures tend to signal the presence of an elite group, the core, which exchanges resources and shares assets frequently, while leaving peripheral firms disadvantaged (Giuliani and Bell, 2005). Other network structures include small-world networks (Watts and Strogatz, 1998), which are characterized by high levels of local clustering (friends of friends tend also to be friends) and short average path length (any actor can reach any other actor in a small number of indirect steps). Some research has pointed out that firms than firms embedded in small world networks are more innovative than firms embedded in different architectures (e.g., Schilling and Phelps, 2007).

Although the existing research highlights the virtues of each type of structure, we would suggest that none of these network ideal types is absolutely superior since their relevance depends heavily on the context and on benefits the network is expected to convey. More importantly, we would agree with Li et al. (2012) that social networks need to be contextualized and their dynamics assessed in order to understand the transformation of clusters. To this end, to study the evolution of local networks, we develop a conceptual framework that includes social, institutional and agentic drivers.

2.2. Strain theory, underperformance and network dynamics

2.2.1. Social drivers of network dynamics in underperforming clusters

Earlier cluster research shows that one of the most important social drivers for the formation of network ties is cohesion, a structural property, which means firms are connected by stable, closed and dense social structures (Giuliani, 2013). The previous cluster research shows that friendship among co-located entrepreneurs can provide the foundation for cohesion in the cluster firms local networks (Varaldo and Ferrucci, 2004; Li et al., 2012). Such relationships stem from individuals' private and intimate spheres (Ingram and Roberts, 2000), which implies that they are trustful and loyal relationships and provide support for the other in times of business or personal need (Westphal et al., 2006). In addition insights from earlier cluster research suggest that physical co-location may accelerate cohesion through the transitive closure of relationships (Giuliani, 2013; Ter Wal, 2014). Transitive closure or transitivity occurs when a new link is formed between two actors that are linked to a common third actor. Sociologists connect the occurrence of transitive closure to balance theory (Heider, 1958), which suggests that an individual is induced to choose new contacts in a way that preserves some consistency and harmony (or balance) within the social group to which she/he belongs (Granovetter, 1973).

While the conventional wisdom would tend to consider that these social drivers work in clusters, we are doubtful about their functioning in underperforming clusters. In particular, we argue that transitivity may be a less strong driver of network change in underperforming clusters compared with friendship. As already mentioned, we draw on strain theory (e.g., Merton, 1938; Agnew, 1992, 2001) to substantiate our claims.

According to strain theory, when individuals experience deprivation and are under pressure to perform or to achieve socially acceptable goals, they may resort to deviant practices to achieve their aspirations and satisfy their needs. We assume that entrepreneurs[2] operating within underperforming clusters will experience negative feelings about the poor performance of their ecosystem and, therefore, will be subject to a general condition of objective strain (Agnew, 1992). In other words, as a group, these entrepreneurs will suffer from a common feeling of dissatisfaction about their current situation, but, at the same time, will feel that their superior performance is being hampered by a set of external constraints (e.g., national institutional weakness and technological backwardness, macroeconomic instability, etc.), which, especially in the context of developing countries, it is difficult for them to overcome. Against this background, strain is expected to act as a (noxious) stimulus for entrepreneurs keen to escape underperformance.

We argue that their condition will likely generate spontaneous peer rejection (Higgins et al., 2010) and induce uncooperative or antisocial attitudes in the cluster. More specifically, objective strain is expected to impede the manifestation of sentiments (namely trust and harmony in social relationships) that are functional to the formation and maintenance of triadic relationships, and for the consequent transfer or sharing of proprietary knowledge with other entrepreneurs and/or competitors in the cluster (Von Hippel, 1988; Giuliani and Bell, 2005). Thus, stressed by the need to escape their condition of underperformance, entrepreneurs may resort to deceiving others to their own benefit or to behaving in an opportunistic as opposed to a collaborative fashion.

2 In developing our hypotheses, we employ individual-level theory, on the assumption that the owner/entrepreneur's choices will reflect the cluster firms' connections. Because of the relatively small size of the firms in our sample, we consider this a reasonable assumption.

Based on this we propose the null hypothesis that transitivity (or transitive closure) will *not* act as significant driver of network change in underperforming clusters:

> Hypothesis 1 (*null hypothesis*): In underperforming clusters, transitivity is not expected to predict the formation of knowledge ties.

At the same time, we argue that the negative emotions experienced by cluster entrepreneurs when they face the adverse condition of being part of an underperforming cluster will be mitigated if the entrepreneurs are linked by pre-existing friendship ties. Entrepreneurs that consider themselves to be friends, based on personal and intimate relationships, are likely to provide one another with support and to provide help in the face of a difficult situation. In this sense, friendship can be considered to alleviate subjective strain (Agnew, 2001), which, in the context of this research, refers to the entrepreneurs' own evaluation of their negative condition. Friendship is expected to reduce the manifestation of negative feelings vis-a-vis other cluster members, and to facilitate the transfer to or sharing of proprietary knowledge with them. Hence:

> Hypothesis 2: In underperforming clusters, pre-existing friendship ties will positively predict the formation of knowledge ties.

2.2.2. Institutional drivers of network dynamics in underperforming clusters

Underperforming clusters have a chronic need for support. Institutions (here, public or public–private organizations and their policies and initiatives) have been cited as important components of successful clusters (Brusco, 1982; Storper, 1997; Porter 1998; McDermott et al., 2009) and celebrated in some of the cluster literature for their role as anchor tenants or well-connected organizations that mobilize other organizations and foster collective growth (Powell et al., 2012). Examples of such organizations include, among others, business associations, private–public associations, liaison offices and business development services centres (Pietrobelli and Rabellotti, 2007). These organizations often deliver local services or implement initiatives or policies to support local entrepreneurs who struggle against underdevelopment.

We argue that these institutions can become safety nets for underperforming clusters by alleviating negative emotions and providing entrepreneurs with some hope that they can ease their stressful conditions. We focus here on two types of institutional pressures: board membership of the local business association, and extent of entrepreneurs' engagement in the local cluster development policy which is meant to stimulate networking and overcome the cluster's growth constraints (Maffioli et al., 2016). Local business associations are organizations that are coordinated by local affiliated entrepreneurs (Alberti et al., 2008) and so we posit that their board members, the local elite group at the core of the association, which orchestrates the association's activities in the cluster, will be likely to interact with one another. Giving and receiving advice, sharing rules, habits, routines and practices and reinforcing their knowledge ties over time can reduce the strain on entrepreneurs and help to overcome the constraints inherent in their underperforming status.

Moreover, we consider that participation in the cluster development policy should generate important normative institutional pressures (DiMaggio and Powell, 1983) on entrepreneurs suffering objective strain. Since development programmes are sponsored and supported by national government, which supplies the resources on which cluster firms depend, we expect them to influence firms to act according to the expectations of the relevant constituencies in their organizational space—for example, government agencies overseeing policy implementation. Hence, entrepreneurs who engage more intensively with policy by undertaking a portfolio of cluster policy network enhancing activities will feel pressure to meet external expectations by forming new knowledge ties. This will increase the chances of the entrepreneur being seen as a legitimate player by the relevant constituencies, and building a reputation for being a responsive and reliable economic actor. This should work to alleviate their stressful condition. We refer to either type of institutional drivers of network change as local institutional pressures and formulate the following hypothesis:

> Hypothesis 3: In underperforming clusters, local institutional pressures are expected to predict the formation of knowledge ties.

2.2.3. Agentic drivers of network dynamics in underperforming clusters

So far we have discussed the social and institutional drivers of network change; however, the heterogeneous nature of entrepreneurs and their firms in the cluster also matter (Rabellotti and Schmitz, 1999). We discuss how cluster underperformance can influence the connectivity choices of entrepreneurs, based on the idea that not all actors will be affected equally by strain (Agnew, 2001). We consider heterogeneity along two dimensions: firms' innovation capacity and firms' openness to non-local sources of knowledge (gatekeeper versus external star).

The conventional wisdom on the innovation capacity of firms in clusters is that this dimension is an important driver of new knowledge ties for two reasons. First, innovative firms are likely to have a larger pool of internal knowledge on which they can draw and which they can transfer to other cluster firms (Giuliani and Bell, 2005); second, innovative firms are likely to be particularly active and may have incentives to connect to different knowledge sources and to tap into local knowledge. For instance, forming new ties with local actors might enable greater leveraging of local knowledge in order to feed the firm's internal innovation processes; non-innovative firms may be less prone to involvement in forming ties.

It is possible, however, that in underperforming clusters these processes are different. While the general level of firm-level innovation is likely to be modest in such contexts, we would expect some heterogeneity that will influence firms' connectivity choices. In particular, we predict that more innovative firms are likely to adopt a 'everyone for themselves' logic, which means that they will seek to distance themselves, as much as possible, from the other cluster members which they consider to be underperforming. Their attitude to these firms will be negative and they will be less likely to engage in local knowledge exchange with them as the network evolves. In other words, we conjecture that the most innovative firms in an underperforming cluster will try to build on their strengths to escape the average condition of underperformance in the cluster, rather than socializing and sharing their relative strengths with others. Accordingly:

> Hypothesis 4: In underperforming clusters, more innovative entrepreneurs will be the least likely to form knowledge ties with other cluster entrepreneurs.

This same logic applies to the other dimension considered here, namely, firms' openness to non-local knowledge. Earlier research on clusters shows that firms that are open to non-local knowledge may be more willing to transfer the acquired knowledge within the cluster; these firms are described as technology or knowledge gatekeepers (Giuliani and Bell, 2005; Morrison, 2008; Giuliani, 2011; Graf, 2011). Research on gatekeepers suggests that the incentives for these firms to transfer knowledge are diverse. In vertical networks, firms are driven by the need to transfer knowledge through the value chain and to provide suppliers with the relevant expertise and support (Morrison, 2008). In horizontal networks, gatekeeping often is justified by entrepreneurs' participation in local communities of practice, where knowledge transfer among rival firms, and advice giving and advice seeking, are commonplace and are rewarded by the expectation of reciprocity in the future (Von Hippel, 1988). Within clusters, gatekeepers are important because, in principle, they enable the rejuvenation of local knowledge through links to distant knowledge sources, which avoids negative lock in (Grabher, 1993; Crespo et al., 2014; Boschma, 2015).

Underperforming clusters may host some firms that are more open to non-local knowledge, but we would challenge the idea that these firms are more willing and able to transfer their superior knowledge locally, through the formation of knowledge ties. Rather, we would suggest that, similar to the most innovative cluster firms, the most open firms will also adopt an 'everyone for themselves' logic and will tend, over time, to privilege their non-local connections over their local ties. Under conditions of objective strain, non-local connections can be perceived as a safe strategy to escape underperformance by resorting to resources that are unavailable locally, while local ties may instead be seen as less productive and resource rich. This leads us to suggest that these actors will be less likely to form new local knowledge ties as the network changes over time. Accordingly:

Hypothesis 5: In underperforming clusters, the entrepreneurs that are most open to non-local knowledge will be less likely to form knowledge ties with other entrepreneurs in the cluster.

3. Setting the context: an underperforming Argentine electronics cluster

The electronics industry in Argentina comprises some 900 firms (Observatorio de Empleo y Dinámica Social [OEDE], 2015) and is geographically concentrated in four regions: the City and Province of Buenos Aires; the city of Córdoba; the city of Rosario and the 'free zone' of Tierra del Fuego. In Córdoba, the context of our research, the first electronics factories were established in the 1970s and benefited from Import Substitution Industrialization (ISI) policies, which had protected consumer goods producers since the 1950s, and the presence of a military aircraft producer (now called Fabrica Argentina de Aviones) and the University of Córdoba. University of Córdoba offered several university degree courses, which provided the local industry with a pool of specialized human resources (the first wave of engineers graduated in 1968). According to Berti (2006), before 1975, there were already 22 firms in Córdoba specialized in consumer electronics production (e.g., TVs, radios and components).

Since this initial phase, the sector has experienced numerous successes and failures (Kosacoff and Azpiazu, 1989; Kaminsky et al., 2009; Kosacoff, 2010; Schorr, 2013), which mirror the evolution of the Córdoba cluster.[3] However, the cluster has managed always to survive. For instance, in 1999, during the Carlos Menem government, the electronics entrepreneurs in Córdoba decided to set up a local business association to promote cooperation and collective action to bolster against external shocks.[4] At the same time, the evidence suggests that the cluster has never been able to achieve frontier knowledge or be internationally competitive.

In what follows, we provide evidence of the underperformance of this cluster during 2005–2012, our period of analysis. To start with, the electronics industry accounted for less than 3% (in value) of the country's exports in 2012,[5] and falls behind the USA, several Asian countries (e.g., South Korea, China, Malaysia, Philippines) and Europe in terms of export value (Queipo, 2010).

Although the Córdoba electronic cluster has survived several shocks and crises, it has never achieved outstanding performance in industrial structure, exports and innovation. It has always been composed of small- and medium-sized enterprises (SMEs), which, generally, have failed to become large scale (for details, see e.g., Table 1 (i), Section 4.1). Their small size is reflected in firm turnover; only 20% of the firms in the cluster achieved turnover higher than USD 1 million per year over the period of observation. With respect to the scale of its market, the data reveal that most firms in the cluster sell to the domestic market. For instance, in 2005, only 28% of cluster firms were exporters and, in some 75% of cases, exports accounted for less than 40% of their total sales. Export rates improved slightly in 2012, but less than half of the clusters were engaged in exporting. In addition, most of their exports were to similar countries in Latin American and/or other developing countries that are less demanding about quality and technological sophistication. From a technological perspective, we observe a low level of innovation in the cluster; no firms filed for an international patent between 2005 and 2012 and, according to Argentine Patent Office (INPI) data, only a few national patents were granted (see Table 1 (iv), Section 4.1). In 2005–2012, only 35% of firms achieved some type of quality certification (e.g., ISO 9001). Finally, according to provincial data, during the period of analysis, the sector's value added grew by 20% less than the average for Córdoba's industry (DPEC, 2017).

3 The cluster has experienced different cycles, such as (i) the ISI period prior to 1976; (ii) the 1976–1983 military dictatorship, which implemented drastic economic reform characterized by openness to imports, financial reform (liberalizing the interest rate), and gradual and increasing devaluations; followed by (iii) the 1983–1989 Alfonsin government, which implemented policies to promote the electronics and computer industries in a bid to increase their international competitiveness (Berti, 2006). In addition to these sectoral policies, the macroeconomic cycle has been characterized by stagnation, inflation and a lower share of industry GDP, culminating in hyperinflation of 3079% in 1989 (Kosacoff and Azpiazu, 1989; Schvarzer, 1996); (iv) the 1991–2002 ''Convertibility Plan'' period, begun during the presidency of Carlos Menem and continued by Fernando de la Rua, that was characterized by a fixed exchange system, accompanied by external economic openness and sales of public assets and services to transnational capitals and (v) the 2003–2012 so-called re-industrialization cycle, which began with a revamping of Argentina's industry activities (Coatz et al., 2015) that was only moderately halted by the onset of the 2007–2009 global financial crisis (EC-IILS, 2011). In this context, we also notice that the electronics industry was relatively unharmed by the financial crisis due to its limited dependence on foreign markets.

4 Note that the Fernando de la Rua presidency culminated in 2001 in an institutional and economic crisis, when national GDP fell by 64% and led to a 'megadevaluation' of 300% in 2002.

5 http://atlas.cid.harvard.edu (last accessed 7 August 2017).

4. Methods

4.1. Data collection and sample

We collected historical data on the Córdoba cluster from several sources, including historical accounts by national experts, archival information, census data and press releases. We also conducted original research in the form of interviews with entrepreneurs in the cluster in 2005 and 2012. In 2013, we held a focus group with 10 key informants, to discuss the main findings from our analysis and validate our interpretations. The first round of interviews, in 2005, was conducted by one of the authors, who also supervised collection of the 2012 data. We identified the universe of firms that were active electronics manufacturers in Córdoba in years 2005 and 2012.

We were unable to access firm-level industry data and used the local Chamber of Commerce as our initial source of information. To ensure that the list of active entrepreneurs in the cluster included the universe of the cluster's active electronics firms, we conducted *ad hoc* interviews with key industry informants beyond the Chamber. From the original list provided by this organization, we excluded firms whose business activity had ceased and firms that only traded in imported electronics good. Thus, our firm sample includes only active manufacturing firms whose main activity at the time of the surveys was classified as electronics.

According to these criteria, our electronics firms samples included 47 firms in 2012 and 50 firms in 2005. We achieved acceptable response rates in both years (76% and 78%, respectively). To ensure the reliability of our network data, we proceeded as follows. First, we asked each respondent to report relationships with all the other firms in the cluster, based on a list of the whole universe of firms. This provided information on whether non-respondent firms were mentioned by the respondents at least once; we used this one-sided information to construct the network. Second, we conducted further, in-depth investigation with local industry experts to avoid false negative errors. The stability over time of the observed patterns of interaction (discussed in the following sections) and the qualitative information derived from these additional checks were reassuring. In particular, non-respondent firms appeared to lack traits that might have influenced the network structure significantly, and were not mentioned by most respondents—some had ceased operations or had migrated to other industries. In addition, the well-bounded nature of the economic system analysed (e.g., we know the population of firms, the numbers are workable, the firms all belong to the same industry) increased response reliability (Calloway et al., 1993). These checks make us reasonably confident that our network data are accurate.

The interviews were based on a structured questionnaire, which we developed and tested prior to the main fieldwork. We conducted three pilot interviews (in both 2005 and 2012) to test our questionnaire, which was revised according to the respondents' suggestions. The final questionnaire included five main sections, designed to collect: (i) general firm-level data (e.g., sub-sector, size, age, etc.); (ii) information on innovation, entrepreneurship and performance (e.g., sales, profits/losses, exports, innovative output, etc.); (iii) network data (e.g., interfirm networks with other electronics firms in Córdoba); (iv) openness to non-local sources of knowledge and (v) degree of

Table 1. Descriptive statistics for 2005 and 2012

	2005 (% of total)	2012 (% of total)
Firm-level characteristics:		
(i) Size:		
Micro (0–5 employees)	34	16
Small (6–20 employees)	37	42
Medium (21–150 employees)	27	39
Large (>150 employees)	2	3
(ii) Age (year of starting up):		
Prior to 1990	45	34.2
1991–2000	37	42.1
2001–2009	18	23.7
(iii) Institutional activities:		
Local business association's board membership (% of firms part of the board)	29	26
Cluster policy participation (% of firms participating in the policy)	76	55
(iv) Innovation and openness:		
Innovation (firms with at least one patent filed at the Argentinean Patent Office)	12	23.7
Non-local connections (% firms with non-local connections)	17	29

participation in the local business association's board and cluster development policy.[6] Since all the firms were relatively small sized, the questionnaire was administered to firm owners. Interviews lasted 60–90 min on average.

Network data collection followed a roster recall method (Wasserman and Faust, 1994), meaning that firms were given a full list (roster) of the other electronics firms in Córdoba in each year, and asked about knowledge transfer. We used the advice seeking and giving questions reported below:

– To which of the firms included in the roster did you transfer business-related knowledge (e.g., technological advice, marketing advice, etc.) in the 3 years prior to the interview?
– From which of the firms included in the roster did your firm receive business-related knowledge (e.g., technological advice, marketing advice, etc.) in the 3 years prior to the interview?

Respondents were asked to indicate the importance they attached to the information obtained, on a 1 (min)–3 (max) Likert scale. For the purposes of this paper, the resulting values are dichotomized.

We codified the questionnaire responses into a dataset, and coded the SNA data into relational data files. Table 1 provides information on the various characteristics of our sample, which we codified as variables.

6 Note that the 2005 and 2012 questionnaires differed. The design of the second survey took into account the content of the 2005 questionnaire and was an improvement on that survey in many respects. However, the variables used in this paper were collected using the same kinds of questions.

4.2. Analysis and variables

The analysis proceeds in two steps. First, we perform a static comparative analysis of the knowledge network structure in the two periods considered (2005 and 2012), based on the set of network structure indicators presented in Table 2 (a). Second, we use SAOM (Snijders et al., 2010) to explain the evolution of the inter-firm network in the cluster. The network involves 47 actors[7] and can be represented as a set of directed 47 * 47 matrices $x = (x_{ij})$, where $x_{ij} = 1$ represents the transfer of knowledge from firm i to firm j (i, $j = 1, \ldots, 47$). SAOM is a class of models designed specifically to account for and model structural dependencies such as, for instance, the transitivity occurring in the network data. SNA is used widely to map and describe the structure of interactions in clusters (Giuliani and Bell, 2005; Vicente et al., 2011) and the SAOM statistical framework is being used frequently to understand how these local interaction structures change and evolve (Balland, 2012; Balland et al., 2013b, 2016; Giuliani, 2013; Broekel et al., 2014).

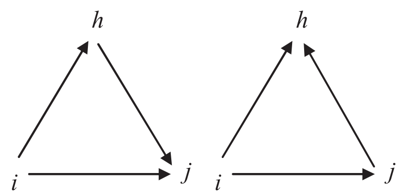
More specifically, the evolution of the Córdoba inter-firm network is modelled as a time-continuous Markov chain $X(t)$, which implies that the change probability depends only on the current state of the network and not on its past configurations. Also, between observations (between 2005 and 2012), time runs continuously and the actors can change only one tie variable at a time. As a result, the changes observed in the overall network are assumed to be the result of an unobserved sequence of micro steps (in which the actors change one tie variable at a time). Only three actors can be connected as the result of a sequence of ties between three pairs of actors. More importantly and, as the name SAOM indicates, the model is actor-oriented. Macro-level network changes reflect the actors' micro-level choices and decisions. These relational choices are based on their preferences and constraints. Network structures change because actors develop relational strategies, based on their embeddedness in the local network structure.

The first dimension of a dynamic network model is timing, that is, opportunities for tie formation. The actors can change their relations with other actors by deciding to create, maintain or dissolve ties at stochastically determined moments (described as the 'rate function' in the empirical analysis). Basically, this conditions network dynamism. At this stage, a logistic regression framework is used to model choice probabilities (Snijders et al., 2010). If the actors have the opportunity to change their relations, they choose a partner in an attempt to maximize their objective function (a linear combination of structural, dyadic and node-level variables) with random perturbations. This maximization attempt is myopic, given firms' limited rationality. In other words, it is based on the short-run and the configuration of the local network.

Following Snijders (2001), estimation of the coefficients included in the analysis is achieved by employing an iterative Markov chain Monte Carlo algorithm based on method of moments. The algorithm simulates the network's evolution and estimates the coefficients, such that the structure of the simulated network, as closely as possible, mirrors the structure of the observed network. In the final stage, the coefficients are held constant in order to evaluate the model goodness of fit and the corresponding standard errors.

7 Between the two observation waves, some actors entered the network and others exited. Composition change is common in analyses of network dynamics and, by specifying a composition change object, following the procedure in Huisman and Snijders (2003), we considered actors only during the time intervals that they were present in the network.

Table 2. Summary of key measures for the analysis of the knowledge network

2(a)	Measures for comparative static analysis of networks
Core–periphery structure	Core–periphery analysis allows the identification of a cohesive subgroup of core firms and a set of peripheral firms that are loosely interconnected with the core (Borgatti and Everett, 1999).
Density	Network density (*ND*) is defined as the proportion of possible linkages present in a graph. *ND* is calculated as the ratio of the number of linkages present, *L*, to its theoretical maximum, $g(g-1)/2$, where *g* is the number of nodes in the network: $ND = L/[g(g-1)/2]$. *ND* values range from a minimum of 0 to a maximum of 1. We measure (i) intra-core density, which considers only core firms; (ii) core–periphery or periphery–core density, which considers the ties between core and peripheral firms, and (iii) intra-periphery density, which refers to the density of connections among peripheral firms.
Final fit	This is a measure that indicates the extent to which the network matches a pure core–periphery structure, on a scale to 0 (no match) to 1 (full match).
2(b)	Measure and effects for SOAM analysis
Social drivers:	
Transitivity	A positive and significant β coefficient means that new ties are formed by closing triads of firms where two connections existed in the previous period. For this effect the contribution of the tie $i \rightarrow j$ is proportional to the total number of transitive triplets of the that it forms, which can be transitive triplets of the type $[i \rightarrow j \rightarrow h;\ i \rightarrow h]$ as well as $[i \rightarrow h \rightarrow j;\ i \rightarrow j]$ 
Friendship	A positive and significant β coefficient means that new ties are more likely to be formed by firms whose owners declared being friends in the previous period.
Institutional drivers:	
Board membership	This is tested through a 'similarity' effect. A positive and significant β coefficient means that ties tend to occur more often among board members, than among non-board members.
Cluster policy	This is tested through an 'ego' effect. A positive and significant β coefficient suggests that the more the firm engages in policy-related activities, the higher the probability that the firm will form new knowledge ties.
Agentic drivers:	
Innovation	A positive and significant β coefficient suggests that the more innovative the firm, the higher the probability that it will form new out-going knowledge ties.
Gatekeeper/ external stars	A positive and significant β coefficient suggests that the more the firm is connected to distant sources of knowledge, the higher the probability that it will form new out-going knowledge ties, thus, behaving as a technological gatekeeper.
Control variables:	
Covariate ego and dyadic effects	This is controlled through some '*Covariate* ego' and 'Dyadic' effects. We control specifically for firm size (number of FTE employees) and firm age. A positive and significant β coefficient suggests that larger/older firms are more likely to form knowledge ties. We control also for the geographical distance (in kilometres) between two firms and their industrial proximity (belonging to the same sub-sector). A positive and significant β coefficient suggests that the more proximate the firms, the more likely they will exchange knowledge. Reciprocity and density are also controlled for.

In line with our conceptual framework, the model includes the following variables (see Table 2 (b)):

1. Social drivers:

- *Transitive closure*: tendency towards closure.
- *Friendship*: tendency for respondents to form knowledge ties based on previous friendship relations.[8]

2. Institutional drivers:
   To account for institutional drivers we use two alternative measures:

- *Board membership*: tendency to form ties among local business association's board members compared with non-members.
- *Cluster policy:* tendency for actors more heavily involved in the cluster development policy (measured by the number of cluster policy initiatives undertaken by them) to form more out-going knowledge ties.[9]

3. Agentic drivers:

- *Innovation*: measures whether the most innovative firms (measured as number of patents filed at the Argentina patent office) are more likely to form more out-going knowledge ties.
- *Gatekeeper/external star*: measures whether firms with non-local or extra-cluster connections to large international firms (buyers, multinational companies, other relevant organizations), which provide them with significant non-local knowledge and skills, are more likely to form more out-going knowledge ties. We measure this as a dummy variable that is coded 0 for no firm connections and 1 otherwise.

In the estimation, we control also for firm-level variables, such as firm size, measured as the number of full-time equivalent (FTE) employees, that might influence the formation of new ties, based on the idea that larger firms may have a higher propensity to form more ties. We control for firm age on the premise that older firms have had more time to embed themselves socially in the cluster. When we test agentic drivers we also include a control for the firms' market openness, which measures firms' exporting rates (% of exports in total sales). We control for other effects, such as geographic proximity (distance in kilometres between firms based on Google Maps) and sectoral proximity (operating within the same specific sub-sectoral niche), which prior research suggests influence network dynamics. Also, as is standard practice in this type of estimation, we include a control for reciprocity (to test for reciprocal relationships) and for density, which controls for the overall tendency of the actors to form ties, and use information on network density (the number of ties divided by the total number of possible ties) to estimate the cost of forming a link (Snijders et al., 2010).

8 The 2005 questionnaire included a question about friendships, which asked respondents to indicate the names of other entrepreneurs in the cluster with whom they considered they had friendship ties beyond purely professional ties.

9 Between 2003 and 2007, the cluster was involved in a pro-cluster policy, a cluster policy promoted by a group of public and private institutions and funded jointly by the Inter-American Development Bank and the Multilateral International Fund, and national sources (Giuliani et al., 2016). The policy involved a set of initiatives to support the creation of collective goods and to enhance connectivity at the local level.

Table 3. Tie changes between subsequent observations

	2012	
2005	0	1
0	1883	143
1	84	52

Notes: Jaccard coefficient = 0.186. Ties with/between firms that did not exist in the first observation period are denoted 0 in this table and were coded with structural zeros for the analysis.

We note also that the network structure is quite dynamic from one observation to the other which leads to a Jaccard coefficient of 0.187, which is low but still above the 0.1 lower bound. Since average degree is increasing (2.8–4.1) from one observation to the next, the convergence of the algorithm is not affected [see Ripley et al. (2016); Manual for RSiena]. To deal with firm entry/exit, we use structural zeros. The composition change method outlined by Huisman and Snijders (2003) leads to similar outcomes. Tie changes are reported in Table 3.

5. Social, institutional and agentic drivers of network change

5.1. The local network is neither too fragmented, nor disconnected

In this section, we adopt a static comparative approach to analyse the structural properties of the knowledge network in 2005 and 2012 (Table 4). We find that, in both years, the network resembles a core–periphery structure, which reinforces over time (final fit 0.62 in 2005 and 0.70 in 2012). We note, also, that intra-core density increased substantially between 2005 and 2012 (0.56–0.89), due, possibly, to the reduction in the number of firms in the core group between 2005 and 2012. It is interesting that this local knowledge network is neither too fragmented nor too disconnected. It displays structural features that are similar to those observed in several other more successful clusters or contexts. This is to say that local networks in underperforming industrial clusters may not necessarily be overly fragile nor lack the necessary level of local embeddedness. Further analyses about the static characteristics of these networks show that core firms are generally more likely to form links based on friendship ties, and to be more engaged in the activities of the cluster development programme. These characteristics hold for both 2005 and 2012. At the same time, core firms in 2012 appear more likely to be local business association's board members, compared with peripheral firms, and slightly more open to non-local connections. Meanwhile, the firms that are more open to non-local connections also decrease their out-degree centrality (i.e., the number of knowledge linkages towards other cluster firms) over time.[10]

10 Note that belonging to the core does not guarantee that these firms will transfer knowledge to other cluster firms since core members may be embedded through their incoming knowledge ties. In fact, only a third of core firms that were open to non-local knowledge were net sources of knowledge (i.e., their out-degree centrality was higher than their in-degree) to other local firms in 2012. Also, firms that are

Table 4. Core–periphery structures

	Density of linkages[a] (knowledge transfer from row to column)		Final fit
2005	Core	Periphery	
Core (n_C = 13)	0.56	0.15	0.62
Periphery (n_P = 37)	0.18	0.02	
2012	Core	Periphery	0.70
Core (n_C = 8)	0.89	0.19	
Periphery (n_P = 39)	0.15	0.02	

[a]Densities are calculated on dichotomous data.

5.2. Explaining network dynamics, and tie maintenance versus tie creation effects

We next employ SAOM to test our hypotheses related to network change. The results of the estimations (see Table 5) are based on 2000 simulation runs; convergence of the approximation algorithm is excellent for all the variables in all the different models (t-values < 0.1). The SAOM parameter estimates can be interpreted as non-standardized coefficients obtained from logistic regression analysis (Broekel et al., 2014). In other words, any given coefficient can be understood as the log-odds of tie formation (knowledge transfer from firm i to firm j) change, with a one-unit change in the corresponding independent variable.

The estimations in Table 5 refer to the evolution of the network without distinguishing the forces leading to new tie formation or tie maintenance. This is the approach commonly adopted in the network dynamics literature (Balland, 2012). Therefore, the creation of a new tie ($x_{ijt} = 0 \rightarrow x_{ijt+1} = 1$) is equivalent to maintenance of a pre-existing tie ($x_{ijt} = 1 \rightarrow x_{ijt+1} = 1$). All models include a set of control variables. Note, also, that following the rule of parsimonious network dynamic modelling (Snijders et al., 2010), we drop non-significant control variables in order to avoid inflated standard errors and to achieve the desired level of prediction with the minimum number of variables.

Model 1 includes the two variables capturing social drivers: transitive closure and friendship. We find a positive and significant effect for transitivity (Model 1), which weakens as we include other variables (Model 3), but remains significant. These results do not support Hypothesis 1, although as we explain later, the significance varies depending on whether we consider new tie creation or tie maintenance effects. In contrast, friendship is not significant, which does not provide support for Hypothesis 2. Model 2 tests for the presence of institutional drivers and shows that both *Board membership* and *Cluster policy* are positive and significant, which is in line with our

more open to non-local connections over time reduce their out-degree centrality (i.e., the number of knowledge linkages with other cluster firms) (from 5.2 to 4). For space reasons, we do not provide details of the further analyses of the characteristics of core and peripheral firms. The results are available upon request from the authors.

Table 5. Results of SAOM for network dynamics

	Model 1		Model 2		Model 3	
	Estimate	Standard error	Estimate	Standard error	Estimate	Standard error
Social drivers:						
Transitivity	**0.215**	**(0.0537)**	**0.1277**	**(0.0724)**	**0.1571**	**(0.0738)**
Friendship	0.2878	(0.4224)				
Institutional drivers:						
Board membership (same)			**0.8683**	**(0.2838)**	**1.0424**	**(0.3290)**
Cluster policy (ego)			**0.391**	**(0.1134)**	**0.5141**	**(0.1326)**
Agentic drivers:						
Innovation (ego)					−0.1391	(0.2345)
Gatekeeper/external star (ego)					**−1.8645**	**(0.5364)**
Controls:						
Market openness (ego)					−0.2466	(0.5312)
Outdegree (density)	−1.2153	(2.6446)	−3.8921	(0.4766)	−4.9306	(0.7887)
Reciprocity	2.8355	(0.4817)	3.2272	(0.5571)	3.635	(0.6541)
Geographical distance	0.014	(0.0184)				
Size (ego)	0.4806	(0.2290)	0.2425	(0.1972)	1.0705	(0.4947)
Sectoral proximity (same)	0.3478	(0.3058)				
Age (ego)	−**0**.0336	(0.0242)				
Basic rate parameter network	12.224	(2.5371)	11.1945	(2.0038)	11.5983	(2.3893)

Note: Significant results for the key variables are in bold. The significance is detectable by observing the estimates and the standard errors' values.

predictions (Hypothesis 3).[11] This means that if two actors are members of the local business association's board they will be more likely to diffuse knowledge to one another and that the higher the firm's level of participation in cluster development policies, the more likely it is to form outgoing knowledge ties. These effects are robust across all specifications. Model 3 tests the effect of agentic drivers and shows a negative and significant effect of *Gatekeeper*, which tells us that firms in the cluster that are more open to non-local knowledge, are also *less* likely over time to form knowledge ties with other cluster firms. This result is in line with our expectation (Hypothesis 5). Note here, that we are measuring firms' connectivity choices in a dynamic context (i.e., as the local knowledge network changes over time), not assessing the extent to which they perform a static gatekeeper role. Therefore, we observe that, over time, firms are less inclined to behave as knowledge gatekeepers in the cluster. At the end of the period of observation (2012), several of the externally connected firms, the darker nodes in Figure 1, are positioned in the semi-periphery or periphery of the network.

11 We tested the effect of Cluster policy-Alter and found no significant effect, indicating that actors are not more likely to receive knowledge if they participate in the cluster policy.

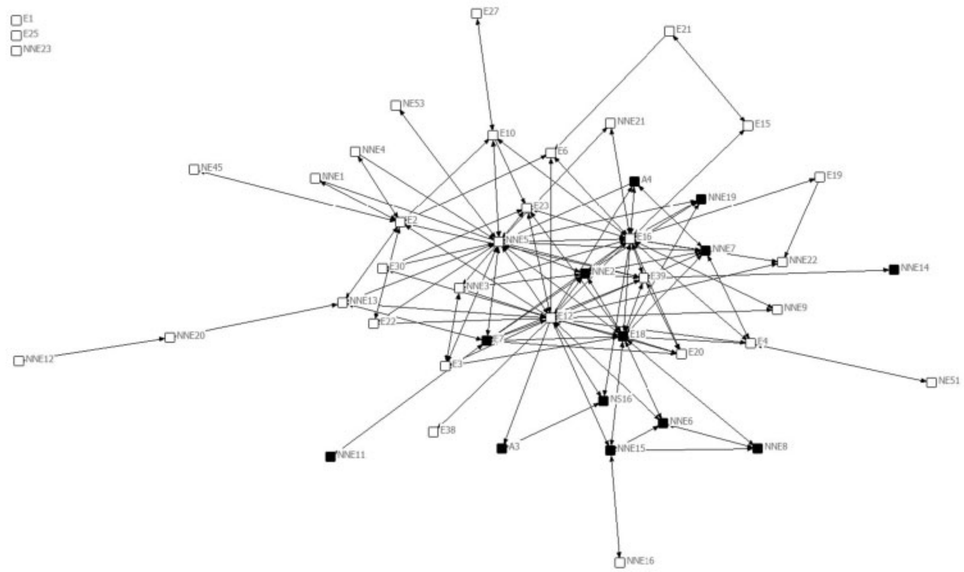


Figure 1. Local knowledge network and firm's openness to non-local connections in 2012. *Notes*: An arrow from *i* to *j* indicates that i transfers knowledge to *j*. Darker and bigger nodes signal firms that are open to non-local connections.
Source: UCINET 6 on author's own data.

Finally, firm-level innovation does not yield significant results, therefore, in contrast to Hypothesis 4, the most innovative firms are not also the least active in generating local knowledge transfer.[12]

To further qualify our results, we model network change by distinguishing between new tie creation and tie maintenance. We focus only on those drivers found to be significant in the previous analysis; lack of significance in the main analysis will not yield significant results when we discriminate between tie creation and tie maintenance (Ripley et al., 2016). Table 6 presents the relevant coefficients.[13] We find an important result for transitivity. If we look at creation versus maintenance, our results become clearer since we find that transitive closure is relevant for the formation of new ties, but *not* for maintaining existing ties. This means that transitivity has some effects on closing triadic relationships, but not in stabilizing existing ones, providing some partial support to Hypothesis 1.

We find also that board members of the local business association do not appear to form more new ties, although tie maintenance appears slightly stronger in this case (estimate 1.4 and standard error 0.9). Moreover, firms that contribute more intensively to cluster policy are less likely to maintain pre-existing ties and more likely to form new ties. Finally, we found no significant result for *Gatekeeper*. This indicates that the

12 Our result on this dimension may also be due to the limited variability observed in the distribution of this variable. We thank an anonymous reviewer for this comment.

13 All estimates include the controls and relevant variables included in Table 5.

Table 6. Testing the effect of tie creation versus tie maintenance

	Estimate	Standard error
Transitivity (endow)	−0.1854	(0.3592)
Transitivity (creat)	**0.6226**	**(0.3302)**
Board membership (endow)	1.3669	(0.8601)
Board membership (creat)	0.6703	(0.8212)
Cluster policy (endow)	**−4.3373**	**(1.0655)**
Cluster policy (creat)	**5.8761**	**(1.3809)**
Gatekeeper/external star (endow)	−109.785	−78.620
Gatekeeper/external star (creat)	83.430	−84.533

Note: Significant results for the key variables are in bold. The significance is detectable by observing the estimates and the standard errors' values.

negative impact of being a gatekeeper is equally strong for both tie creation and tie maintenance.[14]

We discuss these results in Section 6.

6. Escaping underperformance: local institutions as 'safe harbours' and the 'everyone for themselves' logic

Earlier research shows that, among social drivers, transitive closure often explains the creation and/or maintenance of ties in industry clusters (Giuliani, 2013; Balland et al., 2016). Using insights from strain theory (Merton, 1938), we hypothesized that these drivers may work differently in underperforming clusters. We observe that transitivity in industry clusters is not important for the maintenance of ties, although we find that it does lead to the formation of new ties by closing the triad. We interpret this as meaning that entrepreneurs operating in conditions of objective strain may be poorly interested in stabilizing existing ties, unless, as we discuss later, these firms are under institutional pressures to do so. Our results suggest that strain may instil scepticism about existing relationships, and endanger their stability through time, possibly because the condition of general cluster underperformance may convey to the entrepreneurs that the existing ties are leading nowhere or are not allowing them to escape their condition of underperformance. One of our interviewees suggested that

> . . . there were some activities [we did jointly with others] which did not lead to the expected returns . . . you know . . . for firms of this small size like ours, it is necessary that the returns are more concrete. If people don't see the returns of their joint activities with others, they get demotivated, and get disconnected . . . to a small firm like ours it is very costly to nurture linkages with other companies of the cluster, we simply don't have people who can spend time and effort in that. [Focus group member]

14 Ripley et al. (2016, 14) state that 'separating the contribution of an effect into two functions requires more of the data, and if a given effect is similarly strong for the creation and maintenance of ties the statistical power will decrease by this split'.

This quote is not a direct explanation for lack of stability in triads, but it indirectly illustrates why some firms may decide not to stabilize pre-existing relationships. This entrepreneur felt vulnerable and suggested that for small firms it is too difficult to cope with linkage failures and invoked a form of psychological distress (demotivation) as a reason for non-maintenance of existing ties.

The introduction of institutional pressures provides additional insights. Our results suggest that a group of core firms, mostly local business association' board members, contribute to strengthening the hierarchical structure of the local network over time, reflected by our results for reinforcement of the core–periphery structure. Board members generally constitute the core of the local network and board membership prevents tie destruction, which is in line with the idea that the cluster relies on the existence of a strong group of firms whose connections have remained stable over time. A focus group member mentioned the role of core firms as follows:

> there is a group of 'central' firms that is very strongly connected one to another, we are very close to each other, and we live this day by day after so many years working so hard ... when I face a problem, I have no problem in contacting another entrepreneur in the cluster and ask for help or advice on how to solve it. I know I can always count on that and this has been like that for many years where we had to face numerous difficulties and external perturbations ... [Focus Group member]

In connection to these considerations, respondents note that the local business association—founded in 1999 as a response to external shocks (see Section 3)—played a key role for the survival of the cluster, it 'saved it from death', as explained in the following comment:

> the projects which have been promoted by the local business association have often saved us from death. In the past, due to numerous shocks the industry had to face, many firms in Buenos Aires and elsewhere were forced to exit the industry, while we could survive thanks to the projects and collaborative approach of the firms that are part of the board [of the association] ... [Focus Group member]

Next, the results for the role of cluster policy in network dynamics show that this kind of institutional pressure was effective in generating some change, with new ties being formed and old ones discontinued. A possible interpretation of this result is that, based on their participation in the cluster policy, entrepreneurs made efforts to build 'something new' out of the policy initiative and, therefore, sought new partners in preference to consolidating existing relationships.

This effort might be explained by the need for the entrepreneurs to appear to be legitimate actors and to demonstrate their willingness for successful implementation of policy, in order to impress key constituencies (e.g., local government agencies and funding bodies) in the hope of future support. Alternatively, insights from the focus group suggest that participation in the cluster policy has led entrepreneurs to engage in new collaborations and joint initiatives, which boosted their morale. As one respondent put it, these new collaborations were 'very exciting' and 'worth defending and making them grow'. These words indicate that the cluster policy may have triggered a renovated enthusiasm among entrepreneurs, because it could 'save' them from underperformance, and mitigate their strainful condition accordingly.

Overall, these results suggest that institutional drivers appear to be quite effective for fostering connectivity in underperforming clusters, which is in line with earlier research (McDermott et al., 2009; Perez-Aleman, 2011). We further contribute to these studies by suggesting that the condition of strain faced by entrepreneurs in underperforming clusters may lead them to view institutional support or initiatives as a positive way to escape falling behind: either by considering them as a 'safe harbour'—as in the case of the business association—or as a 'life-saving raft', as in the case of the cluster policy. However, as discussed later, this finding cannot be generalized to all forms of underperformance in clusters. It also does not mean that these institutions eventually are successful in promoting cluster growth; rather, insights from the focus group seem to suggest that these are functional to cluster survival through time.

The results for agentic drivers are informative. We suggested that the more innovative and/or open firms to non-local knowledge would be less likely to generate new knowledge ties, based on the idea that, in an underperforming cluster, these actors would privilege their own existence over the cluster's growth and prosperity. Our results provide some support for this idea. It seems that firms that are more open to non-local sources of knowledge and, potentially, have the ability to act as technological gatekeepers, are less likely, over time, to establish knowledge ties locally than less open firms. Borrowing from Allen (1977) and Giuliani and Bell (2005), this connectivity choice may progressively lead to more 'external stars' in the cluster, that is firms that contribute little or nothing to the rejuvenation of the local knowledge pool, despite their access to global knowledge.

This result can be understood as, when operating in an underperforming cluster, the strongest firms will assume an 'everyone for themselves' mentality. In line with the intuitions of strain theory, these firms may consider there to be little payoff from engaging in new knowledge relationships or in strengthening existing ones with other local actors and see the priority as 'saving themselves' from lagging in an underperforming context. A quote from a focus group participant is illustrative:

> this is something personal ... there's people [entrepreneurs] who have disconnected, because they were not interested anymore ... as soon as they understood that there was nothing more to gain from being connected locally, they enacted the typical anti-social conduct. [Focus Group member]

This evidence provides some support for the idea that if the local knowledge pool is small or shallow (Mudambi and Santangelo, 2016) and, hence, 'there is nothing more to gain', there is a natural tendency to act as external stars which potentially hinders the cluster's accumulation of knowledge (Morrison et al., 2013). Ironically, therefore, in clusters that need more distant connections to reduce local technological capability gaps, the most externally open firms tend progressively to eschew local connections, with the result that the rich social connections in the cluster—reflected in the growing transitivity and importance of local institutional pressures—may not be sufficiently open to avoid cognitive lock-in (Grabher, 1993).

7. Conclusion

Earlier scholarly interest in clusters' network dynamics has generally focused on relatively successful places, whereas this research studies an underperforming cluster.

We ask what drives network dynamics in this context and argue that underperformance engenders objective strain (Agnew, 1992), which causes entrepreneurs to dislike their condition and thus enact adaptive behaviours to alleviate the associated strain or negative emotions. Our interest is in the potential repercussions of strain on connectivity choices. Our analysis deepens our knowledge about underperforming clusters, by proposing a novel theoretical interpretation of firm-level connectivity choices in such contexts. Essentially, the problem is not that these clusters have dysfunctional knowledge networks—that is, networks that are too fragmented or non-existent, but rather that their firms may have chosen to form ties in ways that are functional to the survival of their eco-systems.

Nonetheless, it is apparent that however functional the local network might be, these clusters will remain underperforming if, at least, they are not linked to the wider world. External stars can be a major impediment to this integration, which raises questions for policy about how to avoid the tendency of firms to become into external stars rather than technological gatekeepers. Theoretically, our study adds a piece to a bigger puzzle, by suggesting that social drivers may not operate as well as they might in more successful clusters, and that institutional drivers may function as safety nets to guarantee cluster survival. Also, some agentic drivers showed the expected perverse outcome for network dynamics, since the most externally oriented firms display a growing inclination to eschew local connections and behave as external stars. We interpret some of these findings using intuitions of strain theory, but alternative interpretations are also possible, and our study calls for more research to refine current theories of network dynamics in industrial clusters.

This paper has some limitations and the results should be interpreted with caution. Issues related to external validity are important. We chose the case of an underperforming cluster. We do not suggest that our results are generalizable to other underperforming clusters, which, we believe, will display a variety of network configurations and micro-level drivers and are deserving of individual investigation. There might also be different types or levels of cluster underperformance, which may call for scrutiny and theorizing. In addition, our data do not allow us to assess the relationship between network structures and cluster performance and by focusing exclusively on local networks, this analysis overlooks the multi-scalar nature of networks in industry clusters.

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