SOCIAL NETWORKS AND ENTREPRENEURSHIP: EVIDENCE FROM THE ANTIOQUIAN INDUSTRIALIZATION

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Abstract

This paper explores the relationship between social networks and entrepreneurship by constructing a dynamic social network from archival records. The network corresponds to the elite of a society in transition to modernity, late 19th- and early 20th-century Antioquia (Colombia). I exploit the timing of unexpected deaths as a source of exogenous variation of individuals' network position. I find that individuals better connected at a global level (i.e. more important as bridges in the entire network) were more involved in entrepreneurship. However, I do not find individuals better locally connected (i.e. with a denser immediate network) to be more involved in entrepreneurship. I provide quantitative evidence on the performance of the firms and narratives on the behavior of the entrepreneurs who created them to indicate that these results can be explained by the requirement of complementary resources that entrepreneurship had. These resources were spread out in society and markets worked poorly enough to canalize them to entrepreneurs. Thus, networks operated as substitutes for markets in the acquisition of resources. Hence, this paper highlights how individuals with network positions that favor the combination of a broad set of resources can have a comparative advantage in entrepreneurship.

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1 Introduction

Entrepreneurship, understood in the classical definition of Schumpeter (1934) or Knight (1921), is the process of engaging in new and risky productive activities.[1] Several economic historians consider entrepreneurship a fundamental component of structural change and an essential shaper of the long-run trends of capitalism (see Crouzet, 2008; Mokyr, 1998). In addition, policy makers see entrepreneurship as an instrument for transforming the economy of developing regions and improving the living conditions of their people (see Brown et al., 2017). Therefore, a better understanding of entrepreneurship is fundamental for both intellectual and practical reasons.

Popular opinion frequently sees entrepreneurship as the product of individual exceptionalism. Archetypal entrepreneurs like Henry Ford, Howard Hughes, or Elon Musk are usually described as pure lone geniuses. However, there are plenty of reasons to expect that the social context could affect the emergence of entrepreneurs. More specifically, one should expect that the position of individuals in their social network would relate to their decision to get involved in entrepreneurship.[2] Unfortunately, the difficulties to sytematically observe the social network of individuals and their entrepreneurship decisions has limited the number of empirical studies that explore this question.

This paper deals with this issue by studying the social network of members of the elite of a region in Colombia when they created the first industrial firms of the country. This was an activity completely foreign to them and implied large investments and uncertainty–i.e. they were clear entrepreneurs.

To be specific, I use more than 100 primary sources from 15 archives and around 185 secondary sources to manually reconstruct the social network of the elite of Antioquia in the late 19th and early 20th century–at a time when industry emerged. I estimate how the decisions to found industrial firms were related to the features of the entrepreneur's network. In particular, I focus on two network measures: betweenness centrality, and ego-density. Betweenness centrality captures how important an individual is for bridging the global network, giving a sense of her capacity to access resources sparsely located in the network. Meanwhile, ego-density captures how dense the immediate network of an individual is, offering an idea of the strength and support of her social circle.

[1] This definition is similar to what the current literature in development calls *transformational entrepreneurship* or *gazelles/high-growth firms' entrepreneurship*. This kind of entrepreneurship drives the largest fraction of innovation, wealth creation, and new-job generation in modern economies (see Schoar, 2010; Nightingale and Coad, 2013)

[2] For instance, the literature on development economics and social networks indicates that certain types of network positions foster risk taking and technological knowledge acquisition (see Breza et al., 2015; Conley and Udry, 2010; Banerjee et al., 2013), both of which should favor entrepreneurship.

I present evidence from three different sources of variation. First, I explore if similar individuals, who differed in their network position, had different levels of entrepreneurial involvement over their lives. Second, I analyze if variations over time in the network position of the same individual were associated with different levels of entrepreneurship. Finally, I exploit the unexpected death of members of the elite as a set of exogenous shocks to the network and explore if, after these events, levels of entrepreneurship change.

In the three settings, I find a positive and robust relationship between entrepreneurship and betweenness centrality. Meanwhile, none of the settings provides evidence of an equivalent relationship between entrepreneurship and ego-density.

This evidence, in addition to complementary spatial data and narratives of the period, suggests that social connections operated as supplements for poorly functioning markets. Industrial entrepreneurship was a highly complex activity that required a wide variety of complementary resources. Networks were not able to supply all these resources; therefore, individuals used their social interactions to obtain them. Thus, individuals with network positions that favored the combination of a broad set of resources (i.e. individuals better globally connected) had a comparative advantage in industrial entrepreneurship. Meanwhile, having a supportive social circle that came with high local connectivity did not guarantee accessing all the required resources.

This paper brings a series of methodological innovations that are worth mentioning.

First, in a field like social networks, where data constraints are a primary concern (see Breza et al., 2020), I innovate by exploiting the advantages of historical sources to provide detailed information of social interactions in natural environments. The dataset constructed for this paper follows individuals over their entire lives, identifying their family, friendship, politics, business, intellectual connections, and civil activity ties. In addition, it includes information about all their entrepreneurial projects.

Second, within the intersection between economic history and development economics, the historiographic research behind the data collection of this paper is also innovative. It has a level of complexity–by the extension of the time covered, the amount of sources collected, the origin of those sources, and their qualitative nature–that is infrequently seen in studies that address current policy-related questions with historical data.

These methodological innovations allow me to shed light on the importance of network structure on entrepreneurship in contexts where market failures are regular. More specifically, they allow me to move beyond local interactions, and identify that global connectivity plays a fundamental role in solving the constraints that market failures impose to new and risky productive projects.

This paper relates to several branches of literature.

First, it shares the objectives of an agenda in applied microeconomics that explores the determinants of entrepreneurship. Recent work on this agenda indicates that entrepreneurs are systematically smarter, with more experience in risky behavior, and rather young (Levine and Rubinstein, 2017; Azoulay et al., 2020; Bernstein et al., 2018). This paper goes beyond individual attributes and explores the collective determinants of entrepreneurship.

Second, this paper relates to the literature on social interactions and entrepreneurship in development economics. In particular, works like Fafchamps and Quinn (2016), Cai and Szeidl (2018), and Chatterji et al. (2019) have shown through randomized control trials in Africa, China, and India significant effects of improving the local connectivity of firms and individuals on their managerial practices and performance in the span of months. My contribution to this literature consists on bringing evidence on global connectivity from a natural-environment network that extends for decades.

Third, this paper dialogues with the literature that uses historical episodes to study the effects of social interactions on individual performance (see Costa and Kahn, 2007; Beaman, 2012; Costa et al., 2018). This literature explores a wide variety of outcomes, including health and migration. I expand this literature by bringing entrepreneurial decisions to the analysis.

Finally, there is a long tradition that studies the role of social capital on economic growth (e.g. Zak and Knack, 2001; Francois and Zabojnik, 2005; Lindner and Strulik, 2014.). Specifically, this literature explores if certain patterns of social interactions relate to economies that grow faster. A particular line in this literature offers historical evidence on how social-network phenomena promoted the emergence of new sectors like industry or banking, which enabled modern economic growth. Rose (2000); Musacchio and Read (2007); Schisani and Caiazzo (2016) explore the origins of industrialization, while Greif (2006); Rubin (2010); James and Weiman (2010); Lopez-Morell and O'Kean (2008) do it for banking.[3] I contribute to this line of research by expanding the quality and granularity of the data used. I analyze hundreds of thousands of interactions that span for more a century, connecting this with outcomes at individual level. With this, I am able to provide new evidence on the micro-mechanism behind the emergence of modern sectors, industry, in particular.

The paper is organized as follows: Section 2 presents the conceptual framework that describes how the structure of a person's social network is expected to affect her entrepreneurial behavior. This section introduces, in particular, the discussion around local and global

[3]Most of the attention in this literature goes to the description of how complex productive activities–as industry and banking–were supported in personal networks that offered trust and sanctioning mechanisms. This is a claim famously highlighted by Greif (1989, 1993) as an explanation of why certain merchants established long-distance-trade agreements in the 11th-century Mediterranean, where formal mechanisms for enforcing contracts were not widely used.

connectivity. In Section 3, I present the context on the history of Antioquia, the data collection process, and the empirical strategy. Results are presented in Section 4. Section 5 presents the mechanisms, while Section 6 offers some concluding remarks by contextualizing the results in the research agendas of economic history and development economics.

2 Conceptual framework: The role of network structure

Peer-effects analyses are the dominant approach in development economics and economic history when referring to social interactions (e.g. Bloom et al., 2016; Fafchamps and Söderbom, 2013). This approach focuses on the existence of specific groups to which individuals belong (e.g. classrooms, castes, ethnicities). In that setting, peer-effects analyses explores how an individual's behavior is affected by the behavior of the rest of the members of the group (i.e. her peers).

My analysis takes distance from the idea of individuals belonging to groups of peers; it departs, instead, from the idea that individuals are located in a broad and heterogeneous social network, which has as fundamental feature its structure (i.e. its topology). I find inspiration in the literature on social capital from sociology, which emphasizes how the structure of the network an individual is embedded in provides advantages and constraints to her behavior.

This literature moves around two main postures, one that follows Coleman (1988, 1990), who highlights the role of *network closure* as a mechanism that generates trust, and another that follows Burt (2000, 2005), who focuses on *structural holes* and their capacity to promote innovation.

2.1 Network closure and local connectivity

A network with complete closure is one in which everyone is directly connected to each other. As large networks can hardly have this type of feature, network closure is usually relevant only at local level. Thus, closure is frequently measured with the density of the *ego-network*,[4] that is, the probability that any two connections of an individual are connected among them.[5] Denser networks–i.e. in which a larger fraction of network members are connected directly between them–are networks with higher closure.

[4] An ego-network is the network composed by a focal node–"Ego"–and the nodes to whom Ego is directly connected to–"alters"–plus the ties, if any, among those alters.

[5] Formally, this is the number of ties in the ego-network divided by the number of pairs. This measure is know as ego-density, clustering or transitivity coefficient (see Section 1.1 for details on the construction of the measure).

An individual embedded in a local network with high closure might benefit from it in two ways.

First, she should have a more accurate understanding of what is happening in her surroundings. This is because the quality of information deteriorates as it moves from one person to the next in a chain of intermediaries (Baker, 1984). Therefore, increasing the number of individuals directly connected to each other reduces the number of steps required for making everyone aware of a particular unit of information, improving the speed of transmission and the reception quality of the information. For entrepreneurs, this implies that once certain information gets to any member of a network–e.g. a new regulation, an unexpected change in supply prices–it will disperse more quickly and accurately in high-closure contexts. This makes members of high-closure networks able to be more profitable both in the short and the long run.

The second way in which an individual might benefit from a high-closure network is through social sanction. High-closure environments facilitate collective punishment of free-riding behavior (Jackson et al., 2012). This makes easier for people to trust one another. It reduces transaction costs and should generate incentives to develop highly uncertain productive activities–such as entrepreneurship.

2.2 Structural holes and global connectivity

Bridging a *structural hole* (*brokerage*, as it is known) is another way through which network structure might impact individual outcomes. A structural hole is a situation in which two sub-networks are not connected directly with each other. The underlying idea is that these sub-networks have different types of "original" resources (including information) and their lack of interaction prevents them to share those resources. Thus, brokering these sub-networks represents an opportunity to have access to the different types of resources and to control the flow of them from one side to the other of the structural hole (see Quintane and Carnabuci, 2016). In that sense, there are advantages that emergence from a brokers position, particularly, in tasks where the disposal of diverse strategic resources is important–such as in entrepreneurship.

In real-life contexts, completely isolated sub-networks are fairly uncommon. However, real-life networks do have clusters that are relatively well defined (Watts, 1999) and certain individuals are more prominent than others in bridging those clusters (Stovel and Shaw, 2012). In that sense, in contrast to the local nature of closure, brokerage is a concept that is relevant when thinking about global connectivity.

The traditional way of measuring the capacity of an individual to bridge different parts of

the global network is through the *betweenness centrality index* proposed by Freeman (1979). This measure quantifies the number of times a node acts as a bridge along the shortest path between two other nodes, offering an idea of how important a node is in the communication–or transmission of whatever is flowing through social interactions–in the network as a whole. Individuals with higher betweenness centrality are expected to be more likely to put in touch two random individuals (see Appendix 1.1 for details on the network metrics used).

3 Empirical strategy

3.1 Context: The industrialization of Antioquia

Antioquia is a region in the western part of Colombia. Its formal borders have changed over the years, but for the sake of this paper I will consider what loosely speaking is known as "Great Antioquia", which includes the current departments of Antioquia, Caldas, Risaralda and Quindío. It is a region of approximately 76,000 square kilometers, of mostly mountainous territories (see Figure 1). In 1905, about 14% of the Colombian population lived in this region. The difficult geographical conditions led to exceptionally high transport costs and a long-lasting geographical isolation, both within the region and with the rest of Colombia and the outside world.

Figure 1: Map of Antioquia

Note: This figure presents the map of the area of study. Red dots represent towns. Red diamonds represent cities.

Notwithstanding the geographical conditions, Antioquia was the key region in the emergence of industrial capitalism in Colombia, and a representative case in the Latin-American experience. The industrialization of Antioquia had two salient features which make it particularly appropriate for the purposes of this paper.

First, industry emerged in Antioquia as the result of local efforts. Table 1 shows that the role of immigrants and foreign firms was minuscule. Immigrants owned a 5% of industrial firms, which was an equivalent number to the participation of immigrants in the whole population. This contrasts with the situation in the other industrial poles in the Americas. For example, in Argentina 80% of industrial firms were owned by immigrants, representing almost three times the fraction of immigrants in the population. This fact offers me the confidence that, when observing the industrialization of Antioquia, I am truly capturing local entrepreneurial activity, and not the role of outsiders for which no relevant social-interaction information is available.

Moreover, the population that formed the industrial sector in Antioquia was a quite small and isolated elite. This provides two advantages for my empirical exercise. On the one hand, it is ideal for the endeavor of reconstructing a complete network (more on this in Section 3.2.1). On the other hand, as this elite had no experience in manufacturing–they were mostly miners,

farmers, and merchants–identifying entrepreneurs, which is a usual challenge in most settings, is rather simple in this case. Any member of the elite who decided to create an industrial business was involving in a new risky productive activity, that is, she was an entrepreneur.

Table 1: Industrial Entrepreneurship and Immigration. North and South America

Country	Year	% Owners Immigrants	% Pop. Immigrants	Ratio
Argentina	1900	80	30	2.7
Brazil	1920-1950	50	16.5	3
Chile	1880	70	2.9	24.1
Colombia (Antioquia)	1900	5	4.7	1.1
Colombia (Barranquilla)	1888	60	9.5	6.3
Colombia (Santander)	1880	50	3	16.7
Mexico	1935	50	0.97	51.5
US (5% census sample)	1900	31	13.6	2.3
US (Fortune 500)	various	18	10.5	1.7

Note: This table summarizes information on the industrialization of several countries in the Americas.
Source: (Maloney and Zambrano, 2017)

Second, late 19th-century Antioquia shared most of the fundamental elements of the environments where entrepreneurship has usually been studied in economic history (see Landes et al., 2010) and where it is currently most intensively promoted as a development-policy instrument (see Deaton, 2013; Banerjee and Duflo, 2011). In that sense, the lessons that this episode provides is likely informative of other relevant contexts.

More precisely, late 19th-century Antioquia was a mostly rural society,[6] where the average household lived barely above the subsistence level.[7] Fertility rate was around 7.4, and child mortality above 200‰(Flórez and Romero, 2010). The adult literacy rate was below 40%, and the gross primary school attendance below 30%.[8]

Moreover, poorly functioning markets and a weak state capacity characterized the productive structure of the region. There were various types of inflexible labor institutions, this made a good fraction of the unskilled-labor supply not to be assigned through markets but consuetudinary practices.[9] Skilled labor was hardly available in the region, as higher

[6]More than 70% of the workforce was employed in agricultural or mining activities (Botero, 1888). Moreover, population was quite disperse in space. In the first decade of the 20th century, the region had about 90 municipalities, only six of them had a population larger than 20,000 individuals. The capital, Medellín, had 54,916 individuals and was the only municipality with a population larger than 30,000 (Carreño, 1912). Even Medellín was a quite rural town; 48% of the population lived outside the urban area (DANE, 1976).

[7]Income per capita in Antioquia by 1860s was about 35% of the one the US. Moreover, authors like Brew (1977) and Poveda (1981) describe that regular diets were deeply based on large amounts of cheap carbohydrates and extremely low amounts of animal proteins.

[8]These data come from the 1912 census. The literacy rate was calculated based on the population over 18 years old, while school attendance, based on population between 1 and 12 years old.

[9]By 1863, 10% of the labor force in Antioquia were servants outside agricultural activities (Botero, 1888).

education was constrained to the elites and its supply was limited to one school in Medellín that only offered medicine and law degrees. Access to land was quite restricted as well and landowners faced enormous problems of property rights enforcement.[10] Although financial markets systematically expanded during the period, their capacity was never enough to become the dominant financing source until the mid 20th century.[11] Finally, all this was framed in a context of significant political turmoil that implied widespread uncertainty.[12]

3.2 Data

All the data used in this paper comes from a large-scale historiographical collection, specifically designed for this purpose. This collection implied crossing sources of different nature that incorporated economic, demographic, historical, and biographical data. From this collection resulted two completely new datasets. The first dataset contains information of members of the elite of Antioquia during the 19th and 20th century–i.e. relational data and individual attributes. The second dataset includes the information of industrial firms founded between 1850 and 1930–i.e. firms' attributes and the identity of their shareholders. Eventually, I merged these two datasets, creating an individual-level dataset that contains information on the location of individuals in the network, their attributes, and their industrial entrepreneurship decisions.

Considering that agriculture was the sector in which servitude was more common, it is reasonable to think that the share of the population that worked as servant would be higher than 20%.

[10]By analyzing the data of land titling it is clear the absence of large mass of peasantries in the colonized areas of Antioquia (Palacios, 1979). The great majority of those settlers were unprotected against the interests of the landowner elite, leading to serious juridical, political, and social conflicts (see LeGrand, 1988). By 1912, the share of the rural population that owned the land they lived in was smaller than the national average (Arango, 1977), which was already quite high for international standards.

[11]In Antioquia there was not a stable stock market until the late 1940s and banks did not exist up until the 1870s. After the creation of the first financial institutions, they composed a fairly weak system deeply concentrated in Medellín. In 1903, a financial crisis took out of business all the banks created during the 19th (Mejía, 2012b). The elite from Bogotá created in the 1870s the first insurance company of Colombia. This company monopolized the insurance market for several decades. It exclusively supplied protection against transport losses. By 1880s the company had an office in Medellín. All this took place in a context characterized by a complete monetary instability.

[12]Despite the interest of the local politicians to offer a stable scenario for business, in which private property would be respected (Robinson and García-Jimeno, 2010), in several occasions foreign armies arrived in Antioquia during the 19th century, causing material damages and overthrowing democratically elected local governments. In those processes expropriation was a regular tool (see Botero, 2003).

3.2.1 Relational data and individual attributes

The first part of the dataset presents information of 1,876 people belonging to the elite of Antioquia in the 19th and 20th century. These data offer a detail compilation of the economic, political, and intellectual activity of each individual.

I constructed this dataset by combining two components:

First component (snowball sample): First, I followed a snowball approach, one of the most common methods to extract samples of a global social network. The approach consists in selecting a few subjects presumably well-connected, which lead to future subjects from among their social connections, which, in turn, lead to future subjects from among their social connections, and so forth. Thus, the sample grows as a "snowball." This approach is also common outside social network analysis, particularly in studies of hidden populations, which are difficult for researchers to access, such as drug users or sex workers. This is a non-probabilistic sample method that generates some bias concerns. I deal with those in Appendix 1.3.3.

The starting point of my snowball–i.e. the seeds–were the four largest shareholders of the banking system in 1888. The reason to start with the most important bankers is that banks were the largest firms of the 19th century, both in terms of capital and number of shareholders. In that sense, the largest bankers were, certainly, big fishes in the business community. Therefore, they are expected to be well-connected to the rest of the elite, making them good candidates to start mapping the whole network.

Once I defined the seeds, I collected all the information about their lives available in genealogical sources, business reports, periodic publications, chronicles, historical narratives, and the economic literature of the period.[13] Based on these data I created a biographical profile of each of them. From these four individuals the dataset grew by incorporating their parents, their marital partners, and their sons and daughters.[14] In addition, their most important partners in other activities, such as non-industrial businesses, were also included. For all of these new individuals all the available information was also collected, continuing an identical process of data reproduction emerged from them. The temporal boundaries of the sample were 1740 and 1905–i.e. I did not include individuals born before or after these years. The final result was a sample of 953 people, for whom we have a biographical profile and the

[13] The sources used included more than one hundred documents located over 15 archives, and around 185 secondary sources. A Spanish-version of these data with details on the sources used can be found in Mejía (2012a).

[14] An additional criterion for incorporating an individual in the sample was her appearance in at least two different sources. This, in order to avoid inaccuracies in the identification of individuals.

evolution of their most important social interaction behavior over their life spans.

Second component (expansion by relevant projects): Due to the nature of the snowball method itself, the sample resulting from it is not an appropriate representation of the population. In this case, the sample resulted from the snowball, for instance, overrespresents female participation in the elite population. Women had a minor role in public spheres during the period of analysis–i.e. their participation in business and political projects was small to the participation of men. However, women were quite important in private spheres, and fundamental in the family network. For that reason, it is not suitable to erase them from the sample. Similarly, there are other sorts of bias in the sample related to the overrepresentation of some families and people associated with banking, which cannot be expelled because it would break the network configuration.

Therefore, this second component intends to minimize those biases by expanding the sample through a strategy that does not relate to the starting point of the snowball. The strategy consists in inspecting projects considered representative of the elite's public spheres of interaction–e.g. social clubs, intellectual associations. I include the members of those projects in the dataset. I consider the common participation in a project as a tie between individuals. The sources used for identifying the projects to be included had the same characteristics as those of the first component. The criteria for considering a project was solely its relevance in each sphere; there was no particular bias in this component other than what the historiography considers a relevant project.

Nearly 60% of the individuals recorded in the first component were found in the second component. This fact suggests that the snowball sample represents accurately, after all, the elite of the region, that is, the people that participated in the most prestigious spheres of society.[15] Thus, 923 additional people were included in the sample through the second component. For these new individuals there is no other information than the one related to their participation in the projects. Therefore, they are part of the social networks constructed but there will be no "controls" for them in the empirical exercise.

Once these two components are combined, I have a fairly extensive amount of information on the local elite. Most of the individuals were in their productive lives in the last two decades of the 19th century and the first two of the 20th century (see Figure A8). Overall, the sample seems to be a good representation of the local elite of the period. Appendix 1.3.3 offers details on this.

[15]Despite the ambiguity of this idea, it clearly embodies the classical definition of elite as a small group of people who control a disproportionate fraction of a particular social sphere (Bottomore, 1993).

3.2.2 Firms' data

The second part of the dataset contains information on the ownership of the industrial firms founded during the period. This part is constructed based on founding charters and secondary sources. It includes information about the economic activity of each firm, the capital invested, the location, the patents they registered, the number of workers, the founding and closing dates, and the identity of the founders. Despite the absence of industrial censuses for this period, the quality of business-history studies in the region offers confidence that the data collected include almost all the relevant industrial firms founded until 1930.

The amount of information available varies considerably among firms. I identified 287 firms involved in industrial activities, for which I know their constitution dates and their activity at a granular level. For 125 of them, I have records of their shareholders identity and their capital structure. They had on average 5.4 shareholders. And 96 of these firms had shareholders identified in my network dataset. Additional information about the performance of these firms is available for a subset of them.

The average firm that I perfectly observe was founded in 1908 and closed in 1946. It was located in Medellín, and was focused on the production of food and beverages. It had an initial capital of 17,078 pesos, which meant between 200 and 300 times the yearly income per capita of the region at the moment (Mejía, 2015a). And, by the late 1910s, it had 140 workers.

In general, this is consistent with the most salient narratives of the region's industrial history (see Figure A9). Firstly, the timing of industrial expansion described by authors such as Botero (1985), Davila (2012), and Brew (1977) follows the pattern of my data: a slow increase in the creation of firms in the second half of 19th century, with a small boom during the early 1900s, followed by the massive expansion of the 1910s and 1920s. Secondly, my data describes an industrial sector almost completely dominated by light-industry firms of medium to large size, something that Echavarría (1999) and Montenegro (2002) have extensively shown as well. Finally, as it is also widely accepted by the literature, my data show a concentration of the industrial activity in Medellín and its surrounding area (i.e. Caldas, Envigado, and Bello) with a secondary pole in what is know as the Old Caldas (i.e. Pereira and Manizales).

3.3 Networks

Based on the relational data, I reconstruct the social network of the regional elite and calculate the connectivity attributes of every individual in the network. In order to this, I categorize the social ties in seven general dimensions of interaction. I treat each dimension as an independent network. Initially, I describe the networks as static objects, which is the most common

approach in the literature. Then, I describe the networks as dynamic objects, exploiting their temporal dimension.

3.3.1 Statics

Table 2 summarizes the criteria used in the construction of the networks. These criteria attempt to guarantee the proper identification of significant social interactions, given the type of information available.[16]

The strictness in the inclusion rules of ties brings some costs. Primarily, one might miss a set of ties that played an important role in connecting the network. This might increase the concern of what is known as the *boundary specification problem* (see Laumann et al., 1989). However, this problem applies to every empirical network, and there are ways to mitigate it. Kossinets (2006), for instance, proposes the use of multiple sources of edge nomination and the procurement of multi-modal networks. For his part, John Padgett suggests collecting multiple sources of evidence and triangulating them in order to overcome the challenges of causal identification in network analysis (Fowler et al., 2011). Drawing on both ideas in a hybrid approach, this paper runs its main results on a *complete network*,[17] which gathers the different dimensions of interactions in a multi-modal spirit, drawing those dimensions from several independent sources.

[16]For instance, for constructing the political network, instead of selecting the complete universe of individuals and defining ties as partisan affiliation, I opted for a stricter definition, choosing public servants whose only connection was being part of the same cabinet. This reduces the size of the network, but offers more confidence in the type of interaction described because I have not the sufficient amount of evidence to prove that people with the same partisan affiliation did have a real interaction. Instead, I am certain that those individuals who were part of the same cabinet had a significant interaction in political spheres. In other words, I am minimizing error type I.

[17]The complete network includes every interaction, except those generated in the banking business. The reason for excluding banking ties is that they form an exceptionally large and dense network, whose edges might not even represent real social interactions as we understand them. A way of noticing this is by the high average degree of the banking network: 325.

Table 2: Criteria Used in the Construction of the Social Networks

Network			Nodes	Edges	Weights	Period
Family			All*	Parents, couples, children and siblings	None	1740-1999
Political			Public servants	Members of common cabinets. Direct bosses. Direct subordinates	Number of interactions	1820-1950
NGOs	**Civic**		Members of civic organizations	Members of the same civic organization	Number of interactions	1840-1950
	Guilds		Members of guild associations	Members of the same guild association	Number of interactions	1880-1935
Business	**Modern Sector**	**Banking**	Banking shareholders	Shareholders of the same bank	Number of interactions	1875-1888
		Modern transport	Shareholders of non-animal driving firms	Shareholders of the same company	Number of interactions	1880-1930
		Urbanization	Urbanization shareholders	Shareholders of the same company	Number of interactions	1880-1930
	Traditional Sector	**Agriculture**	Agricultural shareholders	Shareholders of the same company	Number of interactions	1850-1930
		Animal husbandry	Shareholders of animal husbandry firms	Shareholders of the same company	Number of interactions	1850-1930
		Mining	Mining shareholders	Shareholders of the same company	Number of interactions	1750-1880
		Mule driving	Mule driving shareholders	Shareholders of the same company	Number of interactions	1750-1865
Intellectual			Members of intellectual circles	Partners at any intellectual project	Number of interactions	1750-1999
Friendship			All*	Friend. Member of the same social club	None	1750-1999
Complete			All*	All excepting banking edges	Number of interactions	1750-1999

Note: This table presents the criteria used for defining interactions.
**All* means that any individual in the sample could be part of the single network.

In that sense, the complete network gathers a whole spectrum of different relational patterns. On the one hand, the quantity, quality, and type of information and resources that is shared in each of these networks is expected to be different. For instance, while family ties are usually supported by daily and intimate interaction, political ties frequently follow non-regular interactions in which public, rather than personal information, is shared.

A way of observing this is to notice that single networks exhibit different structural features. Table 3 presents the aggregate metrics for each network. They follow the patterns that intuition and historiographical evidence would suggest. Modern-business networks, which require increasing efforts in multilateral cooperation and supportive ties, were larger and denser than non-business networks, which have more stable relational interactions, in which bilateralism dominates.

Table 3: Cross Section: Main Characteristics of the Social Networks

Network	Nodes	Edges	Diameter	Density	Connected Components	Betweenness	Ego-density
Complete	1,876	11,717	14	0.003	8	721.1 (1759.1)	26.37 (35.95)
Family	903	4,781	18	0.001	23	630.9 (1365.7)	5.94 (7.61)
Political	228	320	9	0.0009	14	0.798 (10)	1.45 (10.71)
Friendship	184	979	5	0.0003	23	0.106 (1.86)	5.86 (23.19)
Intellectual	153	723	9	0.0002	11	1.17 (15.2)	5.54 (21.96)
Traditional Sector	162	738	9	0.0002	15	0.067 (1.1)	7.44 (25.73)
Agriculture	83	469	2	0.0001	15	0.0001 (0.006)	4.24 (20.13)
Mining	57	125	5	0.0004	7	0.014 (0.246)	2.30 (14.57)
Animal Husbandry	26	113	1	0.0003	4	0 (0)	1.18 (10.79)
Mule Driving	15	37	1	0.0001	4	0 (0)	0.80 (8.92)
Modern Sector	685	105,871	5	0.03	3	78.5 (1595.2)	35.15 (47.19)
Banking	651	105,653	4	0.03	1	12 (274.8)	34.16 (47.00)
Urbanization	23	75	2	0.0002	3	0.005 (0.21)	1.20 (10.84)
Modern Transport	19	145	2	0.0004	3	0.009 (0.39)	0.13 (1.51)
NGOs	282	4,111	7	0.01	4	0.834 (14.7)	14.46 (34.71)
Civic	193	2,957	7	0.0008	6	0.259 (5.14)	10.00 (29.74)
Guilds	101	1,159	4	0.0003	4	0.009 (0.22)	5.31 (22.32)

Note: This table presents descriptive statistics of the social networks in the static framework. Nodes refer to total number of non-isolated nodes. For the aggregate networks the set of nodes is the union of the single networks' set of nodes. The set of edges is the union of the single networks' set of edges. Edges are weighted by the number of dimensions in which nodes are interacting.Betweenness refers to the average betweenness centrality and ego-density refers to the average ego-density. In parenthesis the standard deviation. Betweenness is escalated by 10^6 and ego-density, by 10^2.

3.3.2 Dynamics

The static analysis pools all the data into one single picture. However, the real structure of the data is dynamic. Individuals are being born, they are dying, and they are forming and breaking relations across time.

Even though it is possible to offer a more granular view of the data, in order to have a sufficiently large sample size for each slice of time, I do a decade-based analysis. Table 4 describes the evolution of the network over time. Consistently with the sampling process, the network grows from the late 18th century, having a maximum size by the 1890s, after which it starts to decay. Nevertheless, for *the core period* (1850-1930)–when we have industrial entrepreneurship information–the network seems to have a stable pattern.

Table 4: Panel: Main Characteristics of the Complete Network

Decade	Nodes	Edges	Density	Diameter	Average Path Length	Betweenness	Ego-density
1770	30	37	0.085	2	1.1	164.2 (899.3)	64.4 (47.9)
1780	62	103	0.054	2	1.2	176.2 (1091.8)	60.7 (48.6)
1790	93	58	0.014	4	2.1	413.5 (1406.3)	18.2 (37.4)
1800	208	243	0.011	11	4.5	1973.0 (7741.5)	28.6 (40.3)
1810	284	371	0.009	13	4.9	2658.1 (9135.1)	28.6 (39.0)
1820	404	557	0.007	13	4.9	2049.8 (7193.9)	29.5 (38.9)
1830	513	885	0.007	11	4.8	2197.8 (7601.8)	30.1 (37.9)
1840	1,162	3,362	0.005	16	4.5	422.9 (1698.1)	24.8 (38.3)
1850	1,363	3,987	0.004	16	4.8	504.8 (1950.3)	28.4 (39.5)
1860	1,500	4,204	0.004	12	4.8	514.9 (2045.5)	27.8 (38.3)
1870	1,617	5,054	0.004	15	4.9	588.6 (2011.5)	30.4 (38.2)
1890	1,762	4,124	0.003	16	4.7	425.9 (1603.0)	26.1 (36.7)
1900	1,411	3,706	0.004	18	4.6	628.6 (2231.1)	29.2 (38.2)
1910	1,287	3,933	0.005	12	4.1	562.6 (2165.0)	31.6 (39.2)
1920	696	3,580	0.015	13	4.2	2771.1 (8896.1)	53.8 (38.5)
1930	491	2,044	0.017	11	3.9	2427.1 (9570.0)	51.3 (39.7)
1940	338	930	0.016	14	4.5	3089.5 (12771.1)	47.1 (42.2)
1950	180	333	0.021	13	4.8	4120.9 (14666.2)	39.1 (42.8)
1960	79	64	0.021	4	1.4	130.67 (627.35)	28.2 (43.1)

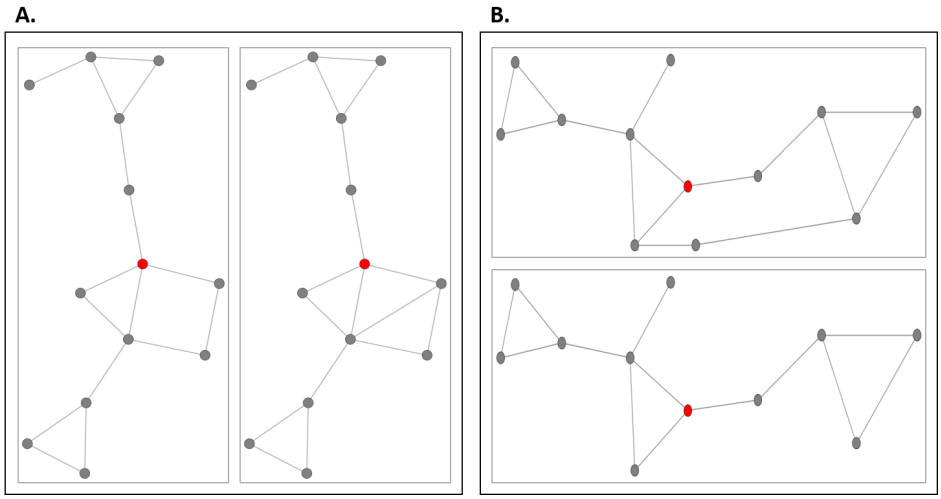
Note: This table presents descriptive statistics of the complete social network in the dynamic framework. Nodes refer to non-isolated nodes. Betweenness refers to the average betweenness centrality and ego-density refers to the average ego-density. In parenthesis the standard deviation. Betweenness is escalated by 10^6 and ego-density, by 10^2.

As expected, the different networks behave differently in time. More specifically, there is extensive variation in the connections' duration across networks (see Figure A10). This variation follows expectations. Non-market ties, such as family, friendship, and intellectual ties have average longer duration than ties with a specific-objective orientation, such as political and guild ties. Once again, this describes the variety of the types of interactions that compose the complete network. The duration of ties implies differential flows of resources and information. For instance, short-term interactions are not well-suited for supporting long-term investments, like founding a risky business.

3.4 Estimation and identification strategy

Following the conceptual framework I present in Section 2, a natural and ideal set of experiments to test the role of the network position on a given individual outcome–entrepreneurship, in this case–would the following: *i)* increasing the ego-density of an individual, keeping everything else constant–her betweeness centrality, in particular. *ii)* increasing the betweenness centrality of an individual, keeping everything else constant–her ego-density, in particular. Panel A of Figure 2 provides an example of *i*, while Panel B, an example of *ii*. Systematic differences in the levels of entrepreneurship resulted from such experiments should indicate the importance of global connectivity or local density on entrepreneurship.

Figure 2: Ideal experiments



Note: This figure represents two ideal experiments in a network setting. Nodes are individuals and edges are connections among them. In Panel A, comparing the network at the right with the network at the left, the red individual has an increase in the density of her ego network. In other words, her local network gets denser, although her global connectivity remains the same. This is done through the formation of a new tie among her neighbors. On Panel B, comparing the network at the top with the network at the bottom, the red individual has an increase in her betweenness centrality. In other words, she gets better globally connected, although her local network remains the same. This is done through the disappearance of a node.

Given the limitations of observational settings, I cannot perfectly execute these experiments in my case study. However, I can provide three sources of evidence that approximate them. Jointly, I consider that they offer a reasonable understanding of how important was the position of individuals in their social network on their entrepreneurial decisions during the industrialization of Antioquia.

First, I provide cross-sectional evidence, exploring if similar individuals, who differed in their network position, had different levels of entrepreneurial involvement over their lives. To do so, I estimate the following naive linear model by OLS:

$$Y_i = \beta + \mathbf{X_i}\alpha + \mathbf{Z_i}\gamma + \varepsilon_i \tag{1}$$

Where Y_i are the number of industrial firms founded by individual i.[18] $\mathbf{X_i}$ is the vector that characterizes the network position of individual i–i.e. betweeness centrality and ego-density.[19] $\mathbf{Z_i}$ represents relevant controls and ε_i is the error term.

[18]I measure entrepreneurship as the number of industrial firms founded by each individual–In Appendix 1.3.1, I provide evidence from alternative measurement approaches.

[19]In theory, these two measures are negatively correlated. Individuals whose alters are highly connected to each other are not supposed to be particularly well connected at a global level, as their alters have similar locations in the network, being good substitutes of them as bridges. In that sense, multicollinearity concerns might arise. However, in my data, the correlation between these two variables is fairly low, -0.02. Then, we can be confident that those measures are capturing different structural features.

In the Appendix 1.3.2, I provide alternative specifications to Equation 1. They address the potential concerns related to having counting data as an outcome variable.

Second, in addition to the cross-individual variation, I estimate a longitudinal model to explore if variations over time in the network position of the same individual were associated with different levels of entrepreneurship. Concretely, for individual i at time t, I estimate the following specification:

$$Y_{it} = \beta + \mathbf{X_{it}}\alpha + \theta_{\mathbf{i}} + \phi_{\mathbf{t}} + \varepsilon_{it} \tag{2}$$

Where θ_i are individual fixed effects, which intend to take into account non-observable confounders that do not change in time, and $\phi_{\mathbf{t}}$ are time fixed effects, which control for aggregate events that varied in time.[20]

Finally, I exploit the unexpected death of members of the elite as a set of exogenous shocks to the network. This quasi-experimental evidence intends to address deeper endogeneity concerns and should be informative of potential avenues of causality. In particular, for individual i, at time t, I estimate the following specification:

$$Y_{it+1} = \beta + \mathbf{D_{it}}\alpha + \theta_{\mathbf{i}} + \phi_{\mathbf{t}} + \varepsilon_{it} \tag{3}$$

Where $\mathbf{D_{it}} = \mathbf{X_{it}} - \mathbf{X'_{it}}$, being $\mathbf{X'_{it}}$ the vector that contains the ego-density and the betweenness centrality of individual i in a synthetic network at period t where nodes that perish unexpectedly during t are removed. In other words, $\mathbf{D_{it}}$ captures the gain or loss in the connectivity of individual i, during period t, exclusively resulted from the disappearance of an individual from the network. As these deaths are sudden and unexpected, $\mathbf{D_{it}}$ should not be correlated with ε_{it}, and its correlation with Y_{it+1} should be indicative of a causal relationship between the variation of i's connectivity and her entrepreneurial decisions.

[20]Notice that both equation 1 and equation 2 capture social interaction through aggregate network measures. In other words, social interaction refers exclusively to individuals' location in the network and not to a function of the behavior of their alters. Henceforth, it is not subject to the *reflection problem* (see Manski, 1993). More broadly speaking, it requires a weaker set of identification assumptions than standard approaches on social interactions in economics (Blume et al., 2015). However, it is particularly susceptible to non-classical measurement error (Breza et al., 2020). This is a concern that I address in Section 1.3.3

4 Main results

4.1 Statics

When looking at the data from a static perspective, the first thing to notice is that industrial entrepreneurship was a rather atypical activity among the elite. Over her lifetime, on average, an individual in the sample founded 0.15 industrial firms with a standard deviation around five times that value.

Exploring the relationship between the network position of an individual and her lifetime industrial entrepreneurship offers two main results (see Table 5). First, betweenness centrality is positively correlated with entrepreneurship. Individuals that were more important bridging the network founded a larger number of industrial firms. In particular, individuals with a measurement of one standard deviation higher in betweeness centrality founded 0.07 more industrial firms than the average of identical (in observable variables) individuals. This is a fairly large coefficient, considering that it represents around 46% of the industrial firms founded by the average individual. Notice that this correlation remains significant even after including the relevant confounders proposed by the literature in economic history and entrepreneurship studies.

Table 5: Cross Section: Industrial Entrepreneurship and Social Networks. OLS

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
					Entrepreneurship					
Betweenness	0.090**		0.090**	0.084**	0.091**	0.087**	0.080**	0.090**	0.084**	0.069*
	(0.037)		(0.038)	(0.037)	(0.038)	(0.038)	(0.037)	(0.038)	(0.037)	(0.036)
Ego-density		0.038	0.007	0.004	0.009	-0.007	-0.005	0.006	0.008	-0.018
		(0.071)	(0.074)	(0.074)	(0.074)	(0.075)	(0.072)	(0.074)	(0.074)	(0.073)
Banker				0.118*						0.060
				(0.061)						(0.064)
Immigrant					0.173					-0.212
					(0.172)					(0.222)
Engineer						0.293*				0.250
						(0.160)				(0.177)
Miner							0.387***			0.339*
							(0.148)			(0.178)
Politician								0.012		-0.000
								(0.078)		(0.079)
Merchant									0.209***	0.170**
									(0.074)	(0.076)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	954	954	954	954	954	954	954	954	954	954

Note: This table establishes the statistically and economically significant correlation between industrial involvement and social networks after accounting for a set of basic controls and an extended set of confounders. The unit of observation is the individual. Industrial involvement is measured as the number of firms founded by an individual during her lifetime. Independent variables are standardized. Robust standard error estimates are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

The second result is the insignificance of the coefficient that captures the relationship between ego-density and entrepreneurship. In other words, there is no evidence that individuals better connected at a local level created more new firms over their lifetimes.

Although these two results come from a naive specification, they consider already a wide range of individual controls, such as gender, partisan affiliation, wealth of family in 1850, being part of a migrant family, having higher education, or having studied abroad, and places

and dates of birth, marriage, and death.

Finally, there is an additional set of relevant results related to individual attributes. In simple correlations, almost every individual attribute that the literature suspects to be associated with industrial entrepreneurship shows a significant coefficient in my setting. However, just a couple of them–being a miner or a merchant–maintain significance in the complete specification. As I will discuss in Section 5, this might shed light on the mechanisms behind the interaction of networks and industrial entrepreneurship.

4.2 Dynamics

To exploit the temporal variation in the data I focus on *the core period* (1850-1930). Before this period there was no industrial activity and I do not record entrepreneurship data for the posterior decades. Results go in the same direction as the static ones (see Table 6). Betweenness centrality is positive and significantly correlated with the creation of new firms. In particular, an increase in one standard deviation in betweenness centrality is associated with a 0.06 new firms created by an individual in a decade, which represents about 80% more firms than the average.

Table 6: Panel: Industrial Entrepreneurship and Social Networks

	Entrepreneurship				
	(1)	(2)	(3)	(4)	(5)
Betweenness	0.121***		0.122***	0.092***	0.060***
	(0.026)		(0.026)	(0.024)	(0.023)
Ego-density		0.017	0.023	0.000	-0.038**
		(0.015)	(0.014)	(0.014)	(0.016)
Individual FEs	Yes	Yes	Yes	Yes	Yes
Time FEs	-	-	-	Yes	Yes
Network Controls	-	-	-	-	Yes
Number of Periods	8	8	8	8	8
Observations	11,256	11,256	11,256	11,256	11,256
Number of individuals	1,806	1,806	1,806	1,806	1,806

Note: This table establishes the statistically and economically significant correlation between industrial involvement and social networks. The unit of observation is individual-decade. The sample period is 1850-1930. Industrial involvement is measured as the number of firms founded by an individual during the considered decade. Robust standard error estimates in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

On the other hand, the coefficient of ego-density, although significant in the preferred specification, is quite unstable across specifications, which makes it difficult to comfortably interpret it as systematic evidence that higher local connectivity was associated with lower entrepreneurship.

4.3 Exogenous network variation

As they are mere correlations, the previous results are compatible with several narratives. To deal with this issue, in Section 1.3, I provide an extensive set of tests to indicate that these results are not spurious. These tests include, but do not limit to, the inclusion of additional controls, the use of different estimation models, and an exhaustive discussion related to measurement error. Overall, I can say that the results above are fairly robust: individuals with higher betweenness centrality systematically created more firms, while those with higher ego-density, did not.

Moreover, I exploit the timing of the creation of firms to indicate that this correlation is not explained by an effect from entrepreneurship to posterior increases in global connectivity. In other words, the previous results do not come from reverse causality.

Although this set of exercises narrow the reasonable interpretations of the evidence I present, plenty of endogeneity concerns remain. To tackle those, I exploit the series of exogenous shocks to the network that the unexpected disappearance of nodes brought. In order to do so, I identify every individual in the first component of the sample that suddenly died during the core period. I will call them *delta individuals*. I observe, in total, 13 delta individuals (see Table A10). In Table A11, I show that delta individuals were not statistically different from the rest of the sample, except for the fact that, as one could expect, they died younger. Delta individuals died, on average, at 35.3 years, while the rest of the sample died at 69.2.

After identifying the delta individuals, I construct a series of synthetic networks where I remove the delta individuals that died during each period. Based on this, and having as reference the original network, I can recognize which non-delta individuals experienced an exogenous variation on their connectivity levels.

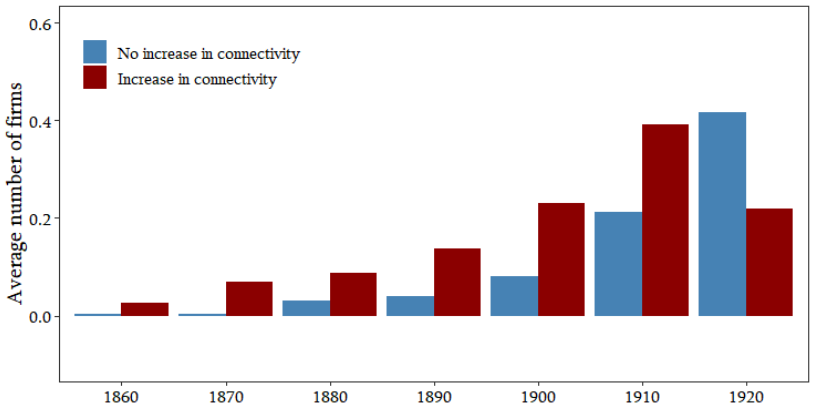
Unfortunately, in most cases, the disappearance of the delta individuals is not enough to generate systematic variation for ego-density measures.[21] However, a handful of random changes in the network–such as the disappearance of delta individuals–does generate a fairly large variation on the composition of the shortest paths in the network, leading to a good amount of change in the distribution of betweenness centrality.

Based on this, we can observe that, except for the 1920s, in every single decade, those individuals whose betweenness centrality increased as a result of the disappearance of delta individuals created, in the following period, more than those whose betweenness centrality

[21] Remember that ego-density is a description of the immediate neighborhood of an individual's network. In real life networks, it is quite unlikely that a handful of deaths could massively modify the structure of most local neighborhoods.

did not increase (see Figure 3).

Figure 3: Creation of new firms. Increase vs non-increase in global connectivity



Note: This figure presents the average number of firms created by decades. It distinguishes between individuals who saw an increase in their betweeness centrality as a result of the disappearance of the delta individuals (orange) and those who did not saw an increase (blue).

This variation supports the results from sections 4.1 and 4.2. Given that the disappearance of delta individuals is sudden and unexpected, we could understand the variation in the betweenness centrality that results from it as exogenous and the higher creation of firms as, most likely, a cause of this variation.

Table 7 shows that this is a robust and statistically significant result across the entire core period. More precisely, Table 7 presents the estimates of Equation 3. On average, individuals who had a one standard deviation higher betweenness centrality in the synthetic network, compared with the original network, created 0.013 new firms in a decade, which represents about 17% more firms than the average.

Table 7: Quasi-experiment: Industrial Entrepreneurship and Social Networks

	Entrepreneurship			
	(1)	(2)	(3)	(4)
Change Betweenness	0.014*	0.014*	0.013*	0.013*
	(0.007)	(0.007)	(0.007)	(0.007)
Individual FEs	Yes	Yes	Yes	Yes
Ego-density Control	-	Yes	Yes	Yes
Time FEs	-	-	Yes	Yes
Network Controls	-	-	-	Yes
Number of Periods	8	8	8	8
Observations	11,241	11,241	11,241	11,241
Number of individuals	1,805	1,805	1,805	1,805

Note: This table establishes the statistically and economically significant correlation between industrial involvement and social networks. The unit of observation is individual-decade. The sample period is 1850-1930. Entrepreneurship is measured as the number of firms founded by an individual during the considered decade. Robust standard error estimates in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

In the appendixes, I provide a set of validity test to show that this quasi-experiment is well-performed. In Appendix 1.3.5, I show that this result does not depend on the particular composition of the delta individuals. Appendix 1.3.6 presents a placebo test, which indicates that the shocks considered do not affect other outcomes that are not supposed to affect.

5 Mechanisms

In a now classic work on entrepreneurship in economic history, Baumol and Strom (2010) argue that "*Far more than other topics in economics, the study of entrepreneurship must turn to nonstatistcal history for the bulk of its evidence*." Inspired on this, in this section, I combine additional quantitative and qualitative evidence to explore why individuals with higher global connectivity were more involved in entrepreneurship. Based on this evidence, I find that the most plausible explanation is that social ties were used to gathered resources in a context where poorly functioning markets could not provide them. Individuals better globally connected could gathered a more diverse set of resources which gave them a competitive advantage at the time of carrying an activity that required to assemble a wide variety of resources, such as entrepreneurship.

5.1 Global bridges were not more innovative, but more successful

The literature on the advantages of brokerage usually emphasizes that it fosters creativity and innovation (see Fleming et al., 2007). In particular, global bridges are expected to have an extraordinary exposure to new ideas and technologies, which should make them more prompt to innovate. Thus, as an important element of entrepreneurship is novelty, a reasonable

first step is to explore if this could be a relevant mechanism behind these paper's results. Interestingly, it does not seem to be the case. At least not in the most immediate way.

There is no good evidence indicating that global bridges were more driven to innovative entrepreneurship. In other words, higher betweeness centrality was not significantly associated with the creation of firms that had more patents or firms in activities with a higher technology intensity (see Table 8).

However, entrepreneurs better globally connected created significantly more successful firms. This suggests that advantages associated with higher global connectivity came from something that helped the existence and survival of entrepreneurial projects in a more general way, which might include–but definitely exceed–technological adoption and innovation.

Table 8: Cross section: Firms' performance and social networks

	Patents		Tech intensity		Success	
	(1)	(1)	(2)	(2)	(3)	(3)
Betwenness centrality	0.002	0.0003	0.014	0.007	0.077***	0.066**
	(0.017)	(0.016)	(0.014)	(0.013)	(0.027)	(0.026)
Ego-density	-0.072	-0.097	-0.022	-0.052	0.111	0.047
	(0.088)	(0.096)	(0.081)	(0.079)	(0.131)	(0.134)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Extended controls		Yes		Yes		Yes
Observations	115	115	115	115	115	115

Note: This table establishes the statistically and economically significant correlation between firms' outcomes and the founders' social networks. The unit of observation is the entrepreneur. Patents are measured as the total number of patents registered by the firms founded by the entrepreneur before 1930 divided by the total number of firms founded by the entrepreneur over her lifetime. Tech intensity is measured as the total number of firms founded by the entrepreneur considered high-technology (i.e. in the sectors chemicals, communication, energy, metal-manufacturing, water) divided by the total number of firms founded by the entrepreneur over her lifetime. Success is the prediction of a principal components analysis that considers the number of firms that *i)* did not reach one year of existence *ii)* did not reach expected life *iii)* went bankrupted *iv)* closed during Great Depression divided by the total number of firms founded by the entrepreneur over her lifetime. Robust standard error estimates in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

5.2 The complexity of industrial entrepreneurship

Following the previous point, interpreting why entrepreneurs who were better connected in the global network created more industrial firms–which were also more successful–requires to explore the nature of industrial production.

Development theorists have thought of industry as a late stage of capitalism, which needs the preexistence of other well-developed sectors such as agriculture and banking (Rostow, 1960; Hirschman, 1958). These sectors are supposed not only to offer the inputs that industry requires, but also to settle broader conditions in the society that favor its emergence–e.g. the formation of wage labor, the consolidation of financial capital, etc. At an entrepreneurial level, this implies that successfully creating an industrial firm is a complex activity. It needs

the combination of a large set of different "ingredients" at the same time–e.g. large amounts of capital, technological knowledge, workers trained in highly controlled environments, etc.

Traditionally, complete and well-functioning markets are expected to provide those ingredients. However, in the late 19th-century Antioquia, that was not the case.

5.2.1 Productive challenges and market failures

Financial constraints To begin with, accessing the capital necessary for carrying a successful industrial endeavor was quite challenging.

On the one hand, the initial capital of industrial firms was fairly large. As I mentioned previously, only 0.05% of the population of Antioquia had a private fortune larger than the capital invested in industry by an average entrepreneur. On the other hand, besides the initial capital requirements, large firms needed a trust-worthy cash flow to support its operations. This was something that the weak financial system of the region could hardly provide.

Consider that, in addition to the limitations described in Section 3.1, the financial system in Antioquia was highly unreliable. For example, Brew (1977) reports how several banks, in 1888, massively canceled loans already assigned to industrial firms. This event put additional pressure over equity and shareholders' connections as funding resources of the companies, leading some of them to bankruptcy.

Second, even in periods of credit expansion, as the 1920s, the frictions in the market were large enough to keep interest rates at high levels–2% monthly for private loans in Medellín and more than 4% in the rural areas (Bell, 1921). Under these circumstances, only exceptionally profitable and robust projects were able to fully rely on banking credit sources for their operations.

Knowledge access Gathering the capital to create and run the firms was not enough. Even after solving this problem, accessing useful knowledge and technology was difficult. By every possible measure, the stock of human capital in the region was low and the education system was highly indifferent to technical training (Safford, 1976).

Mariano Ospina Rodríguez, an influential politician, whose children became salient industrial entrepreneurs in Antioquia, pointed out this flaw in the education system of Colombia in an eloquent way:

> "Our schools, all of them, have the very grave defect of inoculating the youth with political spirit, and as politics is the devourer of wealth, it would be said that

> a youth who can count on some capital to begin to work... is incapacitated by the studies of our schools..." (Barrientos, 1913, p.179)

Under these circumstances, acquiring the knowledge of how industrial production worked implied, in most cases, studying abroad–this is precisely what Mariano Ospina's children eventually did.[22]

There were other short-term alternatives. Bringing foreign experts was one of them. This was a practice that, eventually, cigarette companies adopted. Restrepo (1983) explores records in which it is clear that *La Fábrica de Cigarrillos La Lealtad* and *La Fábrica de Escobar, Restrepo y Compañía* brought Cuban experts on tobacco growing and processing.

Notice that the limitations to access knowledge not only represented a problem for the creation of industrial firms. It also had consequences on their posterior success. Indeed, the arrival of Cuban experts to the cigarette industry resulted precisely from the overwhelming evidence that quality flaws were affecting their competitiveness.[23]

Machinery and supplies imports Even after having the necessary knowledge to carry a successful industrial activity, entrepreneurs needed particular types of physical capital, which were not locally available. This capital, usually large machinery, had to be purchased in foreign markets– England or Germany, in most cases. This implied a quite complex process of acquiring the information about the appropriate machines for a given process and establishing the connections with the foreign companies for making a successful purchase that considered, among other things, the long-term challenges of maintenance. This process required a series of tasks which the average member of the elite of Antioquia was not familiar with–e.g. interactions with a large number of intermediaries, intricate correspondence in foreign languages, and trips of several months to Europe.

Furthermore, transporting the imported machinery to factories in Antioquia was a whole enterprise by itself. In contrast to other industrial areas in Latin America, located over the coast, where the internal transport of the machinery did not imply much more than a calm

[22]This were regular claims among the elites of the region. In 1862, in a letter arranging the studies abroad of one of his children, a merchant says the following:

> "My object in sending him to that country is that he learn some branches [of knowledge] which may be useful in this one. But most especially I desire that he learn mechanics and machinery, not so much theoretically as practically and in the part of most immediate application to our necessities" (quoted by Safford, 1976, p.236)

[23]A similar example in a different activity was *La Ferrería de Amaga*, one of the first hardware companies in Antioquia, which used a certain type of wood that had insufficient heating power for iron production. Several regional historians argue that this problem eventually led to the bankruptcy of the firm (Corradine, 2011).

couple of hours/days trip–e.g. Buenos Aires or Sao Paulo–in Antioquia, this process usually took months in quite harsh conditions. This trip included a 70 day journey by boat from the port in the coast (Barranquilla) to the port in the closest river (Poveda, 1998). Then, reaching the industrial cities implied to cover over 250 kilometers by mule in the difficult mountain conditions described above, which took several weeks.[24] This process brought a whole set of technical challenges and risks. For instance, in 1902, the machinery for the recently created textile firm, *Compañia Antioqueña de Tejidos*, arrived completely broken after the trip from England. This implied a long and extensive repaired by locals, which, eventually, led to the closure of the company (Ospina, 1955).[25]

5.2.2 Non-productive challenges and market failures

Market size The previous challenges were strictly productive. Unfortunately for the entrepreneurs of Antioquia, there were plenty of demand-side challenges as well.

First of all, the geographical isolation and the difficult topography of Antioquia deeply constrained the access to a market large enough to allowed the scale required for most industrial production. For having an idea of the minimum transport costs in the region, a cargo of 125 kilograms transported by mule–the most efficient method for local transport–costed between 20 and 45 cents in a non high-slop area. This was the same cost of transporting one ton in the North of the US by horse carriage (Safford, 2010).

The trade commissioner of the US in Colombia explicitly pointed this as a limitation for the expansion of industrial activity in Antioquia:[26]

[24] A railroad from Puerto Berrío (the port in the closest river) to Medellín was approved in the mid 1870s. It was not finished until the early 1920s, but sections of the railroad were progressively available before. By 1905, only 66 kilometers were available. For the other industrial capitals of Antioquia, the arrival of railroads took longer. They were approved by the early 1910s, and the first sections were available a decade later (Meisel et al., 2014; Martinez and Mejía, 2020).

[25] Accessing raw materials represented a similar challenge. For instance, Restrepo (1983) extensively describes how early textile firms had to import their entire demand for cotton and wool. They deployed a massive campaign to encourage the cultivation of cotton locally. Newspaper articles with messages such as "*We need cotton! Lots of cotton!*" or "*Sow cotton*" were frequent. *Compañia Antioqueña de Tejidos* itself got enganged in a program to provide imported seeds to farmers and committed to buy the entire production of whoever was willing to produce it.

[26] This type of concerns were extremely common, at least, since the late 18th century, when the Spanish envoy, Mon y Velarde said:

> "Those roads have always been the unfortunate beginning of the slowness of trade and the considerable losses suffered by merchants in their transports, and the owners of mules in their high mortality." (Diosa González, 2015, p.36)

> "There can be no question of the industrial development of Antioquia or that this region is rapidly becoming the principal manufacturing center of Colombia, however handicapped it may be by the mountainous nature of the country and the lack of good transportation facilities." (Bell, 1921, p. 232)

Market penetration Even firms that had access to a fairly large market had to compete for that market with well-established incumbents. Manufacturing consumers were used to traditional-style products or industrial imports–which were usually associated with having higher quality, precisely because of their non-local origin.

To illustrate this point, consider the following announcement in a Medellín newspaper in 1873. It was paid by the commercial house *Pedro Uribe F. e Hijo*, which moved its store to a new location:

> "Pedro Uribe F. e Hijo notify the public that they have moved their warehouse to the premises formerly occupied by Mr. Modesto Molina, in front of Mr. Lope M. Montoya's house. They offer the public a new assortment of English and French merchandise and good terms, northern flour of the best quality, and pumps of all styles". (Boletin Industrial, 1873a, p.11)

Notice that the announcement had two components, the information of the new location and the description of the quality of their products based on their foreign origin. There were several paid advertisements of this kind in every edition of local newspapers.

Regional historians have identified this appetite for imports and traditional products as a constrain for local industries. For example, Brew (1977) mentions the experience of local cigarettes against the incumbent Cuban cigarettes, and local beer against the overwhelming preferred *aguardiente*. Most of the local industrial precursors in these sectors closed after a few years.

Political barriers and institutional turmoil If economic constraints were not enough, the political environment of Antioquia–and Colombia, for that matter–was not at all favorable for entrepreneurial activity.

Institutional turmoil was the norm. Seven civil wars broke out during the period. These wars brought the destruction of physical and human capital. A concrete example of how this affected industrial entrepreneurs in Antioquia was the regular practice among combatants to destroyed commercial ships going from Barranquilla to Antioquia, hindering even more supplies imports (Poveda, 1998). Antioquia itself was invaded several times by external armies and the new groups in power frequently persecuted businesspeople from opposite factions.

This was the case, for instance, of Eduardo Vásquez Jaramillo, one of the most important industrial entrepreneurs of the period, who was forced to exile and saw all his properties confiscated by the new liberal government of Antioquia in the late 1870s.

The institutional turmoil had also several more subtle, but not less important, consequences on the entrepreneurial activity. Even when wars did not directly impacted the region, the aggregate instability that came with them was problematic. This was the case of la *Guerra de los Mil Días*, which brought a immense monetary chaos that led to hyperinflation, devaluation, and, eventually, a banking crisis that intensified the challenges of finding reliable sources to finance the operations of industrial firms (Correa, 2009).

5.3 Social ties as means to collect resources

Most of the challenges I refer to originated on the poor functioning of markets as institutions that coordinated decentralized anonymous interactions. This implied that individuals had to rely more intensively on their personal interactions in order to develop their economic activities. To be more precise, different types of personal connections provided different types of resources, which were useful to solve the above mentioned challenges.

In this section, I provide descriptive evidence of how generic interactions with particular types of occupations were functional to deal with specific types of entrepreneurial challenges in Antioquia.

5.3.1 Ties with merchants

Merchants were the backbone of the business elite for centuries in Antioquia. The amplitude of their activities made them contacts particularly functional for an industrial entrepreneur.

On the one hand, they allowed the import of machinery and other supplies. Consolidated merchants had decades of experience importing goods. They had stable connections with foreign markets as well as the knowledge of how to perform these activities and the resources needed for doing so. Entrepreneurs connected to merchants benefited from their experience.

Consider, for example, Carlos Coriolano Amador, the founder of *Fundación de Sabaleta*, one of the most important foundries of the second part of the 19th century. In 1867, he intended to order supplies from *Stiebel Brothers*, a commercial house in London. As Amador was unknown to the British commercial house, one of his partners, James Stiebel, asked Marcelino Restrepo, an important merchant of Medellin who was indirectly connected to Amador, for a reference of him:[27]

[27]Several other merchants had similar type of connections with commercial houses in Europe and offered

> "We have no difficulty in receiving the interests of Mr. Amador and accepting his draft accounts but we do not grant more than 6 months of term for the reimbursement of our invoices. However, before entering into business with said gentleman, I want to know your opinion about him and receive your prudent and experienced advice regarding the responsibility, credit, and commercial concept that said gentleman deserves." (quoted by Botero, 2007a, p.98)

On the other hand, merchants were quite helpful as distributors. They, had control over the distribution channels of local trade, being able to overcome the difficult geographical conditions of the region and the challenging interaction with clients. For example, Bell (1921) describes the extensive reach that the merchants of Antioquia had in Colombian markets:

> "The merchants of Antioquia are actively engaged in expanding their trade with the interior, and traders from Medellín are found in the least accessible regions, even as far west as the platinum-mining country of the Rio Atrato... [They] have the advantage of knowing the country, the credit rating of their clients, and all market and credit requirements." (Bell, 1921, p.231)

Indeed, a good fraction of entrepreneurs were merchants themselves or closely related to them, either through family or friendship ties, using this as a distribution platform. Famously, a branch of the Echavarría family, which were traditional merchants for generations, created in 1907 *Coltejer*, one of the most iconic companies of the industrialization of Antioquia. In the early days, Coltejer used the Echavarría's stores to distribute its products.

Finally, merchants also played an important role influencing consumer taste and behavior. Their support was essential to provide a certain product with the visibility necessary to compete with incumbents. Most of this was done informally in their in-store interaction with customers. However, some of their influence can be seen in the local industrial products they regularly advertise in media outlets. In those advertisements, merchants provided the set of signals that consumers appreciated–the foreign allure, for example.

An example of an industrial firm that benefited from this was the first factory of candles in Medellín. They had a distribution agreement with the commercial house of Francisco Acevedo, who posted on the local newspaper an announcement that said the following:

> "New factory of perfected tallow candles, first in its class established in this city, on the Carretero Road. The owner of this factory has spared no expense in

them to their local contacts. A salient example of this was Francisco del Valle in the 1870s, who was able to reach to other person's suppliers and guarantee that they would pack the merchandise in the preferred way. This was not only done to protect the merchandise during the hazardous trip to Antioquia, but also to minimize import tariffs (Boletin Industrial, 1873c).

order to build it up to the standards of its class, in Europe and America; and it has intelligent operators and all the superior materials for its manufacture." (Boletin Industrial, 1873b)

5.3.2 Ties with engineers

Despite the influence of merchants, proximity to them was not particularly functional to solve the technical challenges that came with industrial entrepreneurship. The essential connections for this purpose were the engineers.

The arrival of foreign engineers to work in the mines of Antioquia in the mid 19th century has been extensively recognized as an important element in the modernization of the mining sector (Poveda, 1987; Botero, 2007b). Their spillovers to the industrial sector have also been well studied by local historians (Mayor, 1984; Mejía, 2015b). Here, I present some of the arguments this literature presents.

To begin with, foreign engineers played a direct role as partners in several of the early industrial endeavours. For instance, Reinhold Paschke, a German engineer who came to work on the mines of the north of Antioquia in 1860, was one of the founders of *Compañía de Cerámica Antioqueña* in 1881, the first industrial firm of ceramics in the region. He was also the director of the company for several years. The rest of the founders of the company were merchants, bankers, and miners with whom Paschke had previously collaborated with or acquaintances of his previous collaborators. While the rest of partners contributed capital, Paschke contribution was its knowledge on the technical dimension of the production.

With time, these engineers inserted into the local elite and started playing a subtler role in the industrialization. The Greiffenstein family shows well this pattern. The engineer, Carlos Greiffenstein Kolleman, migrated from Germany to work on the mines of Tiribí in the late 1850s. By the 1880s, he had already moved to Medellín, married a local woman, and become one of the shareholders and manager of a bank. Two of his sons, Guillermo and Ricardo, became important industrial entrepreneurs. They founded, among other firms, *La Vidriera de Caldas*, the first industrial glass company of Antioquia.

Connections with foreign engineers were useful beyond their technical knowledge and the boundaries of family interactions. Their knowledge and connections abroad were also a valuable asset. For instance, personal letters indicate the role of foreign engineers advising local elite members to acquire education in Europe with an emphasis on technical matters. This was the case of Miguel Vásquez Barrientos, who, in 1857, travelled to Europe to initiate his studies. Miguel was 15 years old. This was possible thanks to the logistic help of James Tyrell Moore, a British engineer working at the mines in Antioquia, and good friend of

Miguel's father (Safford, 1976).[28] Miguel eventually returned to Antioquia and became one of the most important industrial entrepreneurs of the region.

Eventually, the generation of Antioqueños who returned with technical knowledge from abroad generated an environment where this type of knowledge was organically reproduced. A concrete example of this was the creation of *Escuela Nacional de Minas de Medellín*, in 1886. This was an engineering school with a business-oriented perspective. It was an initiative led, among others, by two of the children of Mariano Ospina Rodríguez, Pedro Nel and Tulio, after they earned their degrees in engineering at the University of California in Berkeley. Having an education at Escuela de Minas became a practical requirement for the industrial elite until the mid 20th century Restrepo (2016).

5.3.3 Ties with politicians and intellectuals

Neither connections with engineers or merchants were particularly functional in navigating the challenges associated with the institutional instability of the period. As one would expect, political connections were the key to deal with those challenges.

The proximity between industrial entrepreneurs and the political elite in Antioquia has been extensively studied by local historians (see Uribe and Alvarez, 1988; Restrepo, 2016). This proximity was build over a wide variety of personal connections.

As an example, consider the industrial entrepreneur Guillermo Greiffenstein, whom I introduced in the previous section. He married Gabriela Ospina Pérez, the granddaughter of Mariano Ospina Rodríguez, the former President of Colombia (whom I introduced previously, as well). She was also the niece of Pedro Nel Ospina Vásquez (the founder of Escuela de Minas) and the sister of Mariano Ospina Pérez, both of whom were also industrial entrepreneurs and Presidents of Colombia.

The functionality of these political connections was manifold. Most saliently, the capacity of politicians to define protective measures to favor specific industrial entrepreneurs was quite valuable. Table 9 summarizes some of the public interventions on industrial activity in the region during the period.[29]

[28] Moore was the person who contacted and brought several of the early foreign engineers to Antioquia, including Carlos Greiffenstein (Poveda, 1987). Moore helped several other members of the elite of Antioquia to place their children in technical schools abroad.

[29] All those interventions were made in the context of a national policy that extensively used trade policy for promoting industrialization, in particular, after 1885. For more on this policy see Ospina (1955).

Table 9: Politics Involvement in Industrial Entrepreneurship in Antioquia

Year	Activity	Government Level	Details
1840s-1900s	Schnapps	Regional	Legal monopoly per municipality assigned every 4 years to a private agent through an open bidding
1864	Chocolate	Regional	Legal monopoly for 10 years to a private agent
1864	Iron	Regional	Legal monopoly to a private agent
1885	Candles and stearic acid	Regional	Legal monopoly for 10 years to a private agent
1886-1900	Matches	National	Legal monopoly per department and tariff exceptions to import machinery and inputs
1888	Ceramic	Regional	Subsidy of $4.000 to an existing firm
1893	Ceramic	National	Tariff exceptions to import machinery and inputs and reduction to taxing load over 5 years
1892-1894	Cigarettes	National	Governmental monopoly
1895	Energy	Municipal	Foundation of firm with public and private capital
1904	Textiles	Regional	Subsidized public loan
1910	Wheat flour	National	Additional tariff to imports
1912	Energy	Municipal	Legal monopoly to a private agent
1912	Textiles	Municipal	Tax exceptions for 20 years

Note: This table summarizes the most relevant political interventions for promoting industrialization in this region during the period.
Source: Based on Brew (1977), Restrepo (1983), and Mejía (2015b)

Joint ventures between the local government and private entrepreneurs were also common. An example of this was the creation, in 1896, of *Compañía Antioqueña de Instalaciones Eléctricas*, the first modern energy producer of the country. Two thirds of the company were own by the local state (one third, by the Government of Antioquia; one third, by the municipality of Medellín) and one third, by private businessmen. The three largest private shareholders of the company were the brothers Eduardo and Pedro Vásquez Jaramillo and Carlos Greiffenstein Vélez. Carlos was son of Carlos Greiffenstein Kolleman, the German engineer, and brother of Guillermo, whose connections with politicians I just mentioned. Even better politically connected than the Greiffensteins, were the Vásquez Jaramillo. Pedro was the son in law of Luciano Restrepo, who was governor of Antoiquia in the 1880s. Eduardo, who I introduced earlier, became an influential politician himself after his exile (we was appointed to almost every top position in the region, including the governor of Antioquia), and both were brothers in law of Mariano Ospina Rodriguez, and uncles of Pedro Nel Ospina.

Connecting to intellectuals was an additional way of influencing policy and public opinion towards solving the challenges related to industrial activity. One of the ways in which intellectuals influenced public opinion was through the control of media outlets. Sometimes, these efforts were implicit in the shape of the editorial tone. Some other times, they were quite explicit, as when Emilio Restrepo Callejas, one of the founder of the textile firm, *Compañía de Tejidos de Medellín*, published an article on *La Patria*, in which he called for an urgent policy to increase the grow of cotton in Colombia, as its imports became a bottleneck in the expansion of the textile sector. In the article, Restrepo Callejas says the following:

> The Compañía de Tejidos de Medellín appeals to patriotism and self-interest well understood by all Colombians, to help you establish the cultivation of cotton

> as a common business, either by planting it or by propagating these notions and those that experience teaches, in the peasants who are not books and newspapers arrive. The parish priests and the school teachers they have an immense field to do good. [...] we request the help of everyone who wants to grow cotton and spare the company the choice of lacking raw material [...] *We need cotton! Lots of cotton!.* (as quoted on Restrepo, 1983, p.63)

La Patria was a newspaper in which the intellectual, Antonio María Restrepo, the cousin of Emilio Restrepo Callejas, was the most prominent contributor.

5.3.4 Ties with miners and bankers

Finally, in the absence of a stock market, and considering that joint ventures with the local government were not always possible, connections with bankers and miners were the most effective way of accessing large amounts of capital. Bankers had the liquidity that credit provides. Miners, in addition to their technical knowledge, had the disposal of bullion. Both things were an important part of capital provision in a monetary regime dominated by metal-based currency.

A case in which the synergies of bankers and miners were important for industrial entrepreneurship was the creation of *Fundición de Sabaleta* by Carlos Coriolano Amador.

I already described how Amador benefited from the reference of merchants for the import of machinery to this endeavor. However, to finance this purchase, it was necessary the loans that the banks *Restrepo & Cia.* and *Vicente B. Villa e Hijos* gave to Amador for more than 180,000 pesos (Molina and Castaño, 1987). The connections between Carlos Amador and Luciano Restrepo, the head of *Restrepo & Cia.*, and Vicente B. Villa, the head of *Vicente B. Villa e Hijos*, were plenty. Worth mentioning, Carlos and Luciano were political allies and Vicente and Carlos were co-fathers-in-law. Moreover, the entire foundry project, resulted from Amador's efforts to extend the mining business, inherited from his own father-in-law, to industrial production.

The case of Amador was not extraordinary. One can also see the synergies between bankers and miners in the foundation of founding *Compañía de Cerámica Antioqueña.* Reinhold Paschke work at the Amador's mines, as well as Reinholes Wolff, the second largest investor in the firm. Several of the remaining shareholders were bankers, both as individuals–e.g. Francisco and José María Botero–and as organizations–*Banco de Medellin* and *Restrepo & Cia.*

5.4 The need for complementary resources and global connectivity

Overall, I highlight two things from the previous sections.

First, most industrial activities required solving simultaneously most of the challenges of Section 5.2. For instance, having the capital, but lacking the skills to efficiently import supplies and machinery, was not enough for creating a firm that intended to use a modern technology. In that sense, becoming an industrial entrepreneur was not an issue of having the appropriate "ingredient"–i.e. a particular skill or resource. It was an issue of being able to reach and combine a large set of different ingredients. Let me call this the *complementary nature* of industrial-activity inputs.

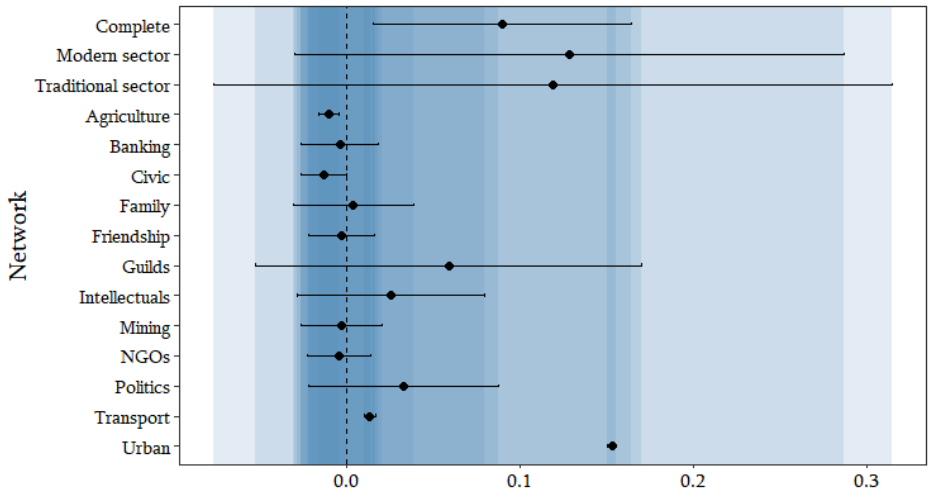
Second, those ingredients were not in the hands of one particular group. They were spread out in society. For instance, bankers had the capital; merchants, the local-distribution know-how; politicians, the power for overcoming entree-barriers, etc. Let me call this the *decentralized nature* of industrial-activity inputs.

The complementary and decentralized nature of industrial-activity inputs implied that, in order to create a successful industrial firm, an individual needed several types of simultaneous connections–i.e. connections with politicians, merchants, miners, etc. In that sense, a network position that permitted to efficiently connect several type of nodes should have offered an advantage for industrial entrepreneurship.

To illustrate this, think about how Amador's foundry required resources that came from miners, merchants, and bankers, with whom he was connected through different networks–e.g. family, politics, friendship. Several of this connections were indirect. His father-in-law opened the doors to mining resources; they were indirectly connected through Amador's wife. Marcelino Restrepo opened the doors to the imports of supplies to Amador's firm; they were indirectly connected through business and friendship ties. As in Amador's experience, the rest of the narratives I present in the previous section indicate that successful industrial entrepreneurs were those individuals that were able to put together resources that were located throughout the entire spectrum of social dimensions.

Figure 4 shows quantitative evidence of this. It presents the results of replicating the cross-section estimation on each dimension of interaction independently. This exercise shows that individuals with higher betweenness centrality in the complete network–which includes connections across dimensions of interactions–were significantly more entrepreneurial. In contrast, higher betweenness centrality in specific networks was hardly at all correlated with entrepreneurship.

Figure 4: Cross Section: Industrial Entrepreneurship and Social Networks. Coefficient Plot



Note: This figure presents the point estimates and 95% confidence intervals of the network-metrics coefficients in 14 regressions. Each regression replicates the 9th specification of Table 5–i.e. it includes controls but not confounders. Thus, each regression considers one particular dimension of interaction–i.e. they refer to the position of individuals in the single networks. The unit of observation is the individual. The dependent variable is industrial involvement, measured as the number of firms founded by an individual during her lifetime. Independent variables are standardized. Coefficients are the difference in the logs of the expected number of industrial firms founded for one standard deviation increase in the predictor variable, given the other predictor variables held constant. Panel A presents the betweenness centrality coefficients and Panel B, the ego-density coefficients.

This supports the idea that global connectivity was relevant as a means to gathered resources broadly dispersed in society. Such a task require, not to be well connected within a given community–i.e. having high betweenness in a single network–but to be well connected across communities–i.e. having a high betweenness in the complete network.

Additionally, evidence in support of this mechanism comes from spatial variation in the economic structure. More specifically, if the claim that global connectivity played a role in entrepreneurship because of its potential to gather diverse resources that markets could not provide is true, betweenness centrality should have been more important for entrepreneurs in communities with lower market development (see Figure A13 for a map of the spatial distribution of market development).

Table 10: Cross Section: Industrial Entrepreneurship and Social Networks. Negative Binomial. Market-Development Interaction

	(1)	(2)	(3)	(4)	(5)	(6)
			Entrepreneurship			
Betweenness	0.211***	0.223***	0.189***	0.184***	0.171***	0.169***
	(0.064)	(0.068)	(0.062)	(0.061)	(0.058)	(0.058)
Market Development	0.106*	0.115**	0.090	0.088	0.099*	0.099*
	(0.055)	(0.058)	(0.060)	(0.059)	(0.057)	(0.058)
Betweenness x Market Development		-0.043	-0.038	-0.050*	-0.072**	-0.072**
		(0.030)	(0.028)	(0.030)	(0.029)	(0.029)
Banker			0.688***	0.715***	0.631***	0.635***
			(0.213)	(0.210)	(0.218)	(0.221)
Engineer				0.437	0.193	0.191
				(0.355)	(0.370)	(0.371)
Miner					1.200***	1.200***
					(0.320)	(0.318)
Politician						0.068
						(0.250)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	926	926	926	954	926	926

Note: This table establishes the statistically and economically significant correlation between industrial involvement and social networks after accounting for a set of basic controls and an extended set of confounders. The unit of observation is the individual. Market development is measured at birth municipality. Industrial involvement is measured as the number of firms founded by an individual during her lifetime. Independent variables are standardized. Coefficients are the difference in the logs of the expected number of industrial firms founded for one standard deviation increase in the predictor variable, given the other predictor variables held constant. Robust standard error estimates are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 10 presents a set of similar specifications to the ones of Table 5, including as independent variables market development and an interaction of betweenness centrality and market development.[30] As expected, market development correlates positively with industrial involvement. In other words, individuals in locations with more developed markets founded more industrial firms. Moreover, the interaction term is negative and significant, once confounders are considered. Thus, the correlation of betweenness centrality and industrial involvement increases with the reduction of market development, which is precisely the mechanism proposed.

Overall, global bridges seem to have been more involved in entrepreneurship because they were in a privilege position to gathered a diverse set of resources through their social interactions, having a higher chance to overcome the constraints that poorly functioning markets imposed on industrial activity.

[30]I measure market development as the ratio of the number of *empleados* over the number of *jornaleros* for municipalities in 1912 Census. Empleados were wage workers, mostly located in urban activities. They operated in a fairly similar way to any current office job. Instead, a jornalero was a worker hired by a traditional labor relation, closely tied to ancestral serfdom institutions. Jornaleros were mostly agricultural workers payed by the day. Frequently, they were payed with production (Bejarano, 1998). Therefore, the ratio of this two types of labor is a scale-free proxy of the relative importance of markets in the economy.

6 Concluding remarks

This paper explores how the position of an individual in her social network relates to her decision of becoming an entrepreneur–i.e. founding firms as a new and risky activity. It provides extensive quantitative and qualitative evidence on social interactions and entrepreneurship from the industrialization process of Antioquia, Colombia, between 1850 and 1930. The evidence that the paper presents comes from a large scale archival research, which contributes, from a methodological perspective, to an expanding generation of studies in economic history that extract individual data from a numerous set of unconventional sources (e.g. Clark and Cummins, 2015; Xu, 2018; Blanc and Wacziarg, 2020).

The results of the paper indicate that social connections operated among the elite of Antioquia as supplements for poorly functioning markets. Industrial entrepreneurship was a highly complex activity that required a wide variety of complementary resources. Networks were not able to supply all these resources; therefore, individuals used their social interactions to obtain them. Thus, individuals with network positions that favored the combination of a broad set of resources (i.e. individuals better globally connected) had a comparative advantage in industrial entrepreneurship. Meanwhile, having the supportive social circle that came with high local connectivity did not guarantee accessing all the required resources and, therefore, such type of network positions did not provide an equivalent advantage for entrepreneurship.

These results are consistent with the theoretical literature that highlights the importance of group diversity in individual performance and problem solving (Hong and Page, 2001, 2004; Lazer and Friedman, 2007). Furthermore, this paper expands the evidence on the correlation between social networks and productive activities in developing regions. Moreover, this paper brings new mechanisms to the discussion. While most of the literature identifies in networks either devices that foster contract enforcement and risk sharing (Greif, 1989, 1993; Dupas and Robinson, 2013; Breza et al., 2015) or that allow the diffusion of innovations (Conley and Udry, 2010; Banerjee et al., 2013; Cai et al., 2015), this paper highlights that social networks play a crucial role as a general method for collecting resources.

I am confident that the evidence presented in this paper, and the mechanisms it describes, can shed light on the emergence of entrepreneurship in other contexts. Landes et al. (2010) present an extensive overview of entrepreneurship in history, which shows that most of the key behaviors described here were prevalent among entrepreneurs in a wide variety of historical episodes. A good example of this is how Joel Mokyr, in his chapter on the British Industrial, emphasizes that entrepreneurs used social interactions to gathered resources and deal with productive complementarities.[31]

[31] In Mokyr's own words:

> "The successful entrepreneur in the Industrial Revolution, as I shall argue, was not necessarily

Similarly, the literature on entrepreneurship in development studies indicates that the constraints to entrepreneurship that individuals in Antioquia faced about a century ago are fairly similar to the ones that people in developing regions currently face. Market failures are pervasive, formal institutions are weak, and local businesspeople struggle to adopt high-potential technologies. In such contexts, solving a particular constraint is not enough, and the poor performance of policies that intend to foster entrepreneurship that tackle a single constraint is evidence of this (see Shane, 2009; Brown et al., 2017). This paper suggests that multi-objective interventions are necessary. It also indicates that promoting social interactions among the business community, which envisions diversity and the exploitation of complementarities, is a tool worth considering within such policies.

a many-sided person who could do it all, as maintained by Charles Wilson (1963, 175). What he represented was one side of the business (either technical or managerial), having the ability to identify a need or an opportunity, then cooperate with others who possessed a different comparative advantage to take advantage of it. Such cooperation often took the form of partnerships or market transactions at arm's length, although a personal element was rarely missing altogether... Entrepreneurial success was based on such successful transactions, not necessarily on a multitalented genius who could do it all." (p.186 Mokyr, 2012)

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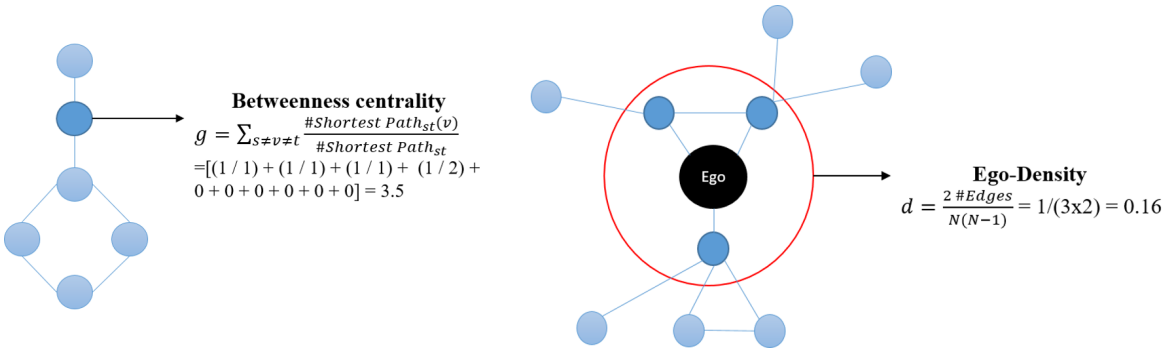
Appendixes

1.1 Network metrics

There are several indexes of betweenness centrality and ego-density. I use the most frequently used in the literature. Both indexes have predefined algorithms available in the *igraph* package of R and Python.

Figure A1: Betweenness centrality and ego-density



Note: This figure presents two networks and the estimates of betweenness centrality and ego-density for one of their nodes.

Similarly, degree, eigenvector centrality, and closeness centrality are constructed following the default algorithm of the igraph package (see Csardi and Nepusz, 2006).

1.2 Data collection

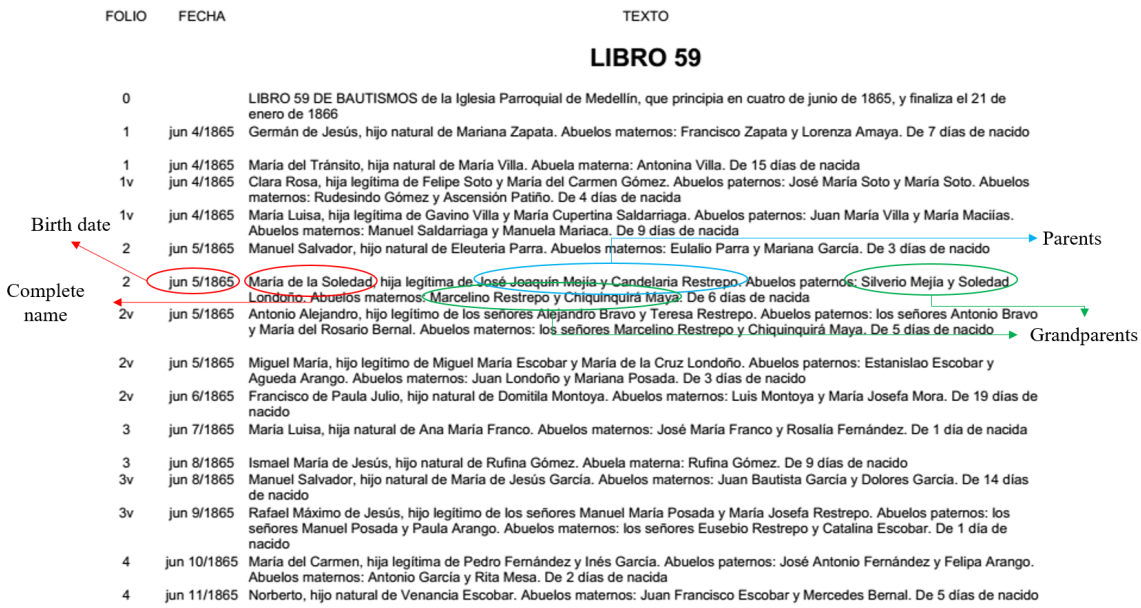
I use a large variety of sources for constructing the data used in this paper. This included more than 100 primary sources (located over 15 archives across Antioquia) and around 185 secondary sources. All the sources were manually transcribed. I used a double-check criterion to maximize the accuracy of the information presented. Individuals must have been identified in at least two sources for being included in the sample. The match of the individuals across sources was also performed manually.

The data-collection work started in April 2010 with the first component of the relational data. It ended in May 2015 with a final update of the firm data. A preliminary version of the relational data with details on the sources used can be found in the form of a biographical dictionary in Mejía (2012a). Missing data on dates was extrapolated from information of family members.

The following section presents examples of some of the sources used.

1.2.1 Examples of the primary sources used

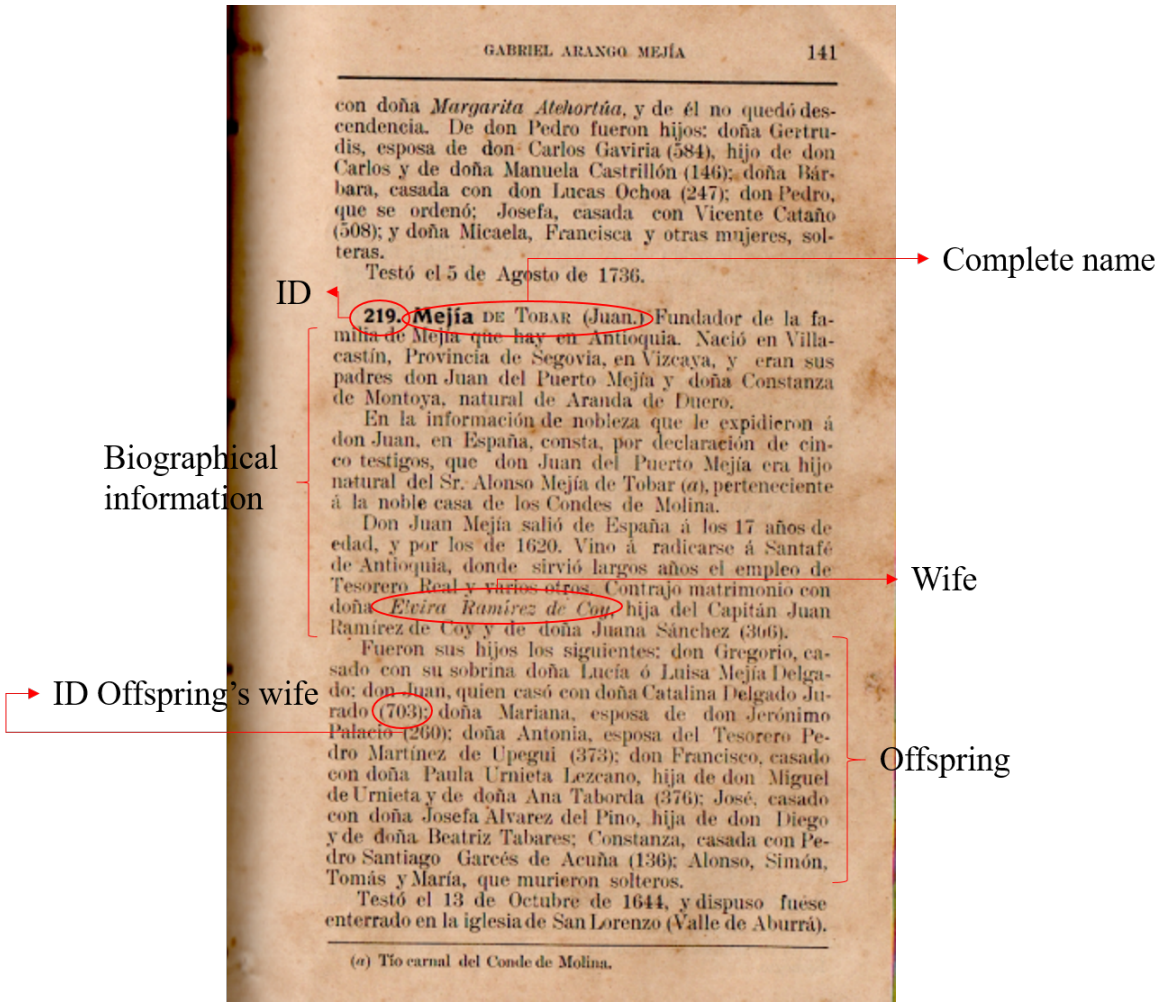
Figure A2: Sample of Baptism Records. Medellín, book 59, June 1865-January 1866.



FOLIO	FECHA	TEXTO
		LIBRO 59
0		LIBRO 59 DE BAUTISMOS de la Iglesia Parroquial de Medellín, que principia en cuatro de junio de 1865, y finaliza el 21 de enero de 1866
1	jun 4/1865	Germán de Jesús, hijo natural de Mariana Zapata. Abuelos maternos: Francisco Zapata y Lorenza Amaya. De 7 días de nacido
1	jun 4/1865	María del Tránsito, hija natural de María Villa. Abuela materna: Antonina Villa. De 15 días de nacida
1v	jun 4/1865	Clara Rosa, hija legítima de Felipe Soto y María del Carmen Gómez. Abuelos paternos: José María Soto y María Soto. Abuelos maternos: Rudesindo Gómez y Ascensión Patiño. De 4 días de nacida
1v	jun 4/1865	María Luisa, hija legítima de Gavino Villa y María Cupertina Saldarriaga. Abuelos paternos: Juan María Villa y María Maciías. Abuelos maternos: Manuel Saldarriaga y Manuela Mariaca. De 9 días de nacida
2	jun 5/1865	Manuel Salvador, hijo natural de Eleuteria Parra. Abuelos maternos: Eulalio Parra y Mariana García. De 3 días de nacido
2	jun 5/1865	María de la Soledad, hija legítima de José Joaquín Mejía y Candelaria Restrepo. Abuelos paternos: Silverio Mejía y Soledad Londoño. Abuelos maternos: Marcelino Restrepo y Chiquinquirá Maya. De 6 días de nacida
2v	jun 5/1865	Antonio Alejandro, hijo legítimo de los señores Alejandro Bravo y Teresa Restrepo. Abuelos paternos: los señores Antonio Bravo y María del Rosario Bernal. Abuelos maternos: los señores Marcelino Restrepo y Chiquinquirá Maya. De 5 días de nacido
2v	jun 5/1865	Miguel María, hijo legítimo de Miguel María Escobar y María de la Cruz Londoño. Abuelos paternos: Estanislao Escobar y Agueda Arango. Abuelos maternos: Juan Londoño y Mariana Posada. De 3 días de nacido
2v	jun 6/1865	Francisco de Paula Julio, hijo natural de Domitila Montoya. Abuelos maternos: Luis Montoya y María Josefa Mora. De 19 días de nacido
3	jun 7/1865	María Luisa, hija natural de Ana María Franco. Abuelos maternos: José María Franco y Rosalía Fernández. De 1 día de nacida
3	jun 8/1865	Ismael María de Jesús, hijo natural de Rufina Gómez. Abuela materna: Rufina Gómez. De 9 días de nacido
3v	jun 8/1865	Manuel Salvador, hijo natural de María de Jesús García. Abuelos maternos: Juan Bautista García y Dolores García. De 14 días de nacido
3v	jun 9/1865	Rafael Máximo de Jesús, hijo legítimo de los señores Manuel María Posada y María Josefa Restrepo. Abuelos paternos: los señores Manuel Posada y Paula Arango. Abuelos maternos: los señores Eusebio Restrepo y Catalina Escobar. De 1 día de nacido
4	jun 10/1865	María del Carmen, hija legítima de Pedro Fernández y Inés García. Abuelos paternos: José Antonio Fernández y Felipa Arango. Abuelos maternos: Antonio García y Rita Mesa. De 2 días de nacida
4	jun 11/1865	Norberto, hijo natural de Venancia Escobar. Abuelos maternos: Juan Francisco Escobar y Mercedes Bernal. De 5 días de nacido

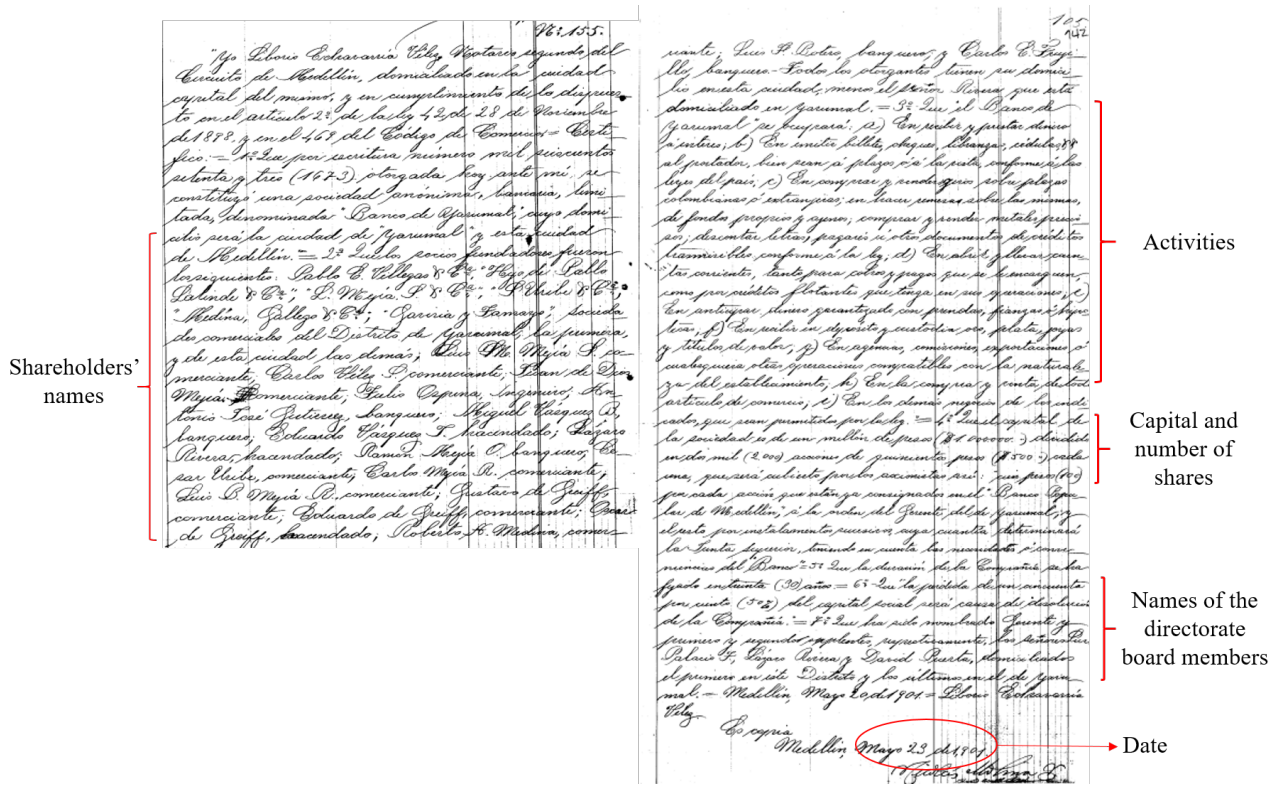
Note: Sample of a baptism book. This figure presents one page of a baptism book. In baptism books, priests recorded the names of every child baptized, in addition to the complete names of their parents, and grandparents. The large majority of the Antioquia's population during this period was catholic. In addition, the Catholic Church was, by far, the most capable institution in the region. It had a strong control over its congregation, being baptism a ritual strongly enforced. Thus, baptism books are an exhaustive source of information for the entire population. Unfortunately, baptism records have not been systematically conserved. Thus, I only had access to a non-random sample of books from several locations.

Figure A3: Sample of a Genealogical Study. Gabriel Arango's Genealogies. Mejia Family



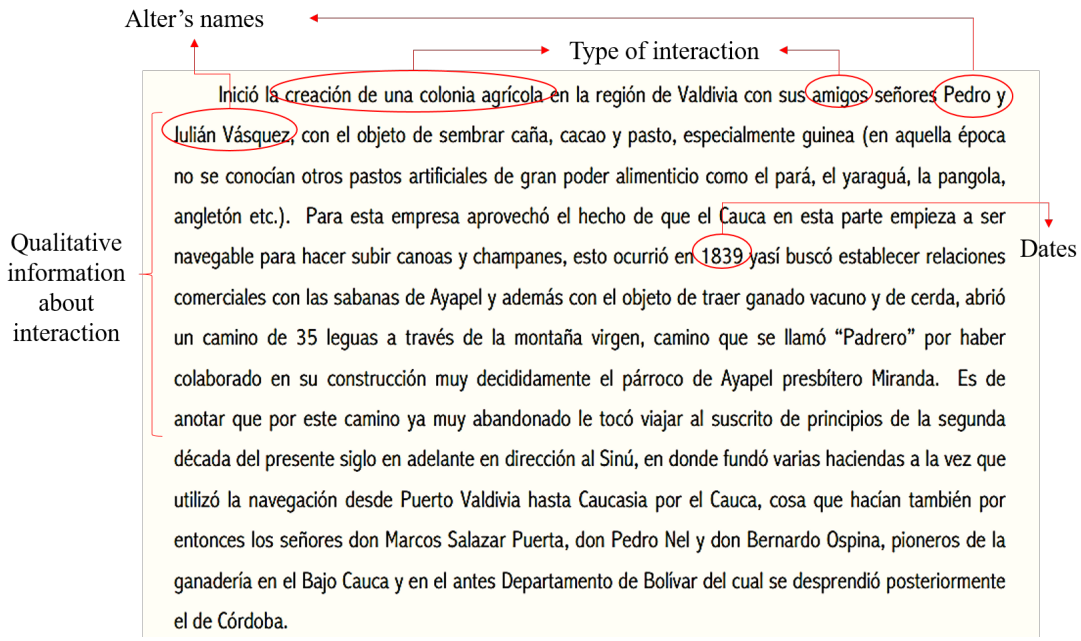
Note: Sample of a genealogical study. This figure presents one page of a genealogical study. Genealogical studies are documents made by local scholars (or genealogy enthusiasts), frequently published, that systematize the genealogical origins of several lineages. This page presents the information of the first Mejia that arrived to Antioquia in the genealogy of Arango (1911). It includes the complete name of the person, the complete name of his wife and offspring. It also offers details on the dates and places of birth and death. Moreover, it includes an ID that allows to trace the offspring's information in other sections of the same source. The exact information available varies across individuals and genealogical study. I used several genealogies in addition of Arango (1911). All of them share similar attributes.

Figure A4: Sample of Constitutional Document. Banco de Yarumal. 1901



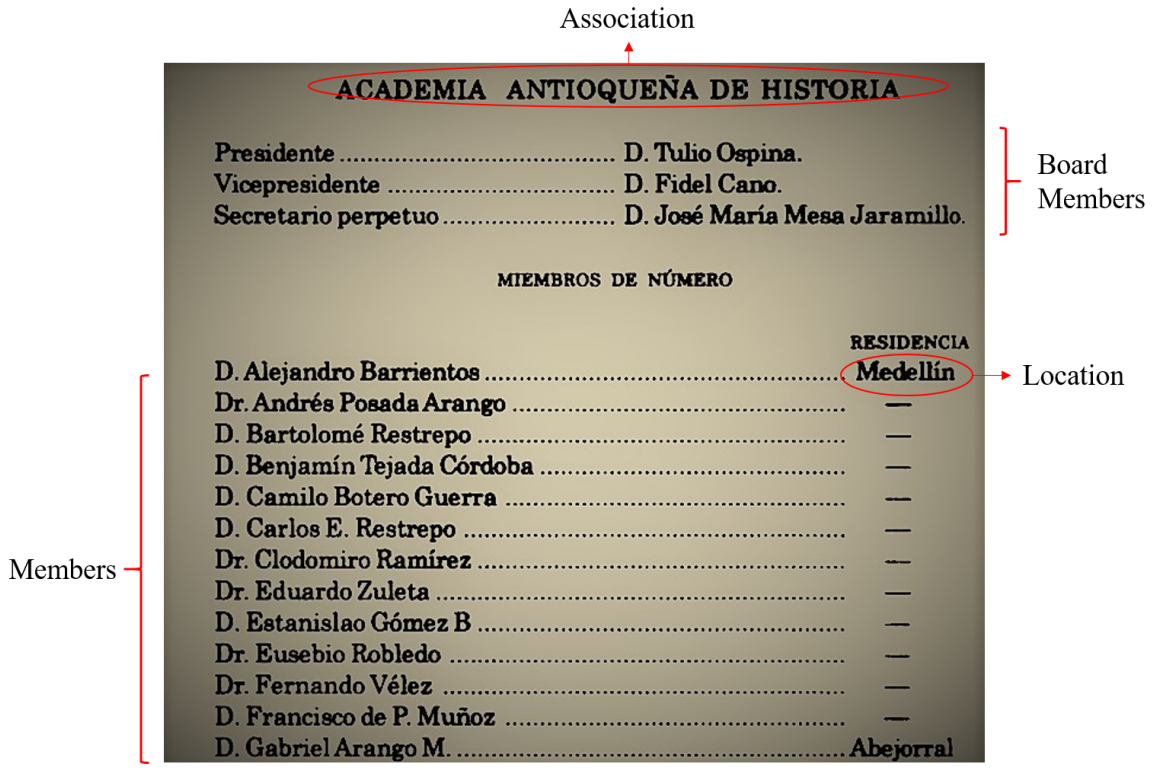
Note: This figure presents the entire constitutional document of a bank in northern Antioquia, *Banco de Yarumal*. It includes the name of every shareholder of the firm, the activities performed by the firm, other equity structure details, and the name of the board members. All this, at the time the firm was founded. In fact, the formal foundation of a firm was the creation itself of this document. Most of the information on business networks comes from this type of sources. Constitutional documents are also an essential element of my industrial-firm dataset.

Figure A5: Sample of Narratives and Entrepreneurial Studies. Echavarria (1971)



Note: This figure presents a fragment of a narrative by Echavarria (1971). Echavarria belong to the elite of Antioquia and was an entrepreneur himself. In this document, published as a memoir by the local Academy of History, he shares his memories of the business activity of the region. This type of sources are rich in qualitative information on the content of ties and attributes of individuals. They agglomerate a good fraction of the knowledge transmitted through oral methods, which is hardly available in any other type of source. The attributes and the information available in this type of sources vary significantly from one author to the other.

Figure A6: Sample of Elite's Associations. Academy of History



Note: This figure presents a fragment of the list of the members of the Academy of History. The Academy of History was an organization that promoted local history. The literature has identified that this project–as well as the other projects I consider in the sample–was an elite's initiative. Some of this type of projects had completely philanthropic purposes. In this case, I consider that every pair of individuals that were members of the Academy of History at the same time had an intellectual tie.

Figure A7: Grave of José María Amador (a delta individual)

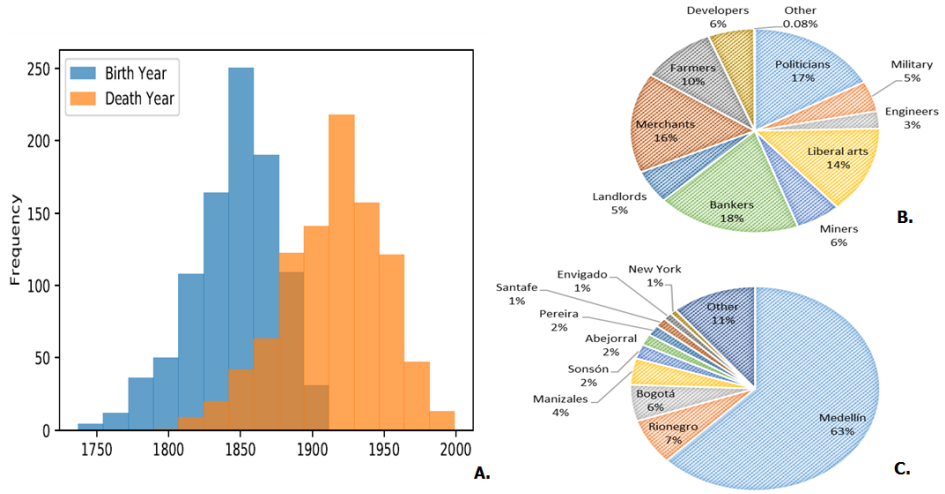
Note: This figure presents a picture of the grave of José María Amador, one of the delta individuals. After returning from his honeymoon, Amador fell sick with an illness called "love disease" by the doctors at the moment. After agonizing for several weeks, he died November 1893. Currently, it is considered that the cause of his death was a tuberculosis that evolved from contracting a sexually transmitted disease.

1.2.2 Sample representativeness

Overall, the sample I construct is coherent with our qualitative knowledge of the elite of the region during the period. For a sense of the type of population the elite was, consider the composition of the activities of the sample presented in Figure A8. They coincide with the qualitative evidence described by authors like Brew (1977), Poveda (1981), and Davila (2012), who suggest how generalized commercial and banking activities were among the elite. Minor (but not infrequent) participation in other activities is also identified by those authors as a common pattern of this population. The fact that 116 people (9% of the sample) were founders of industrial projects is reasonable for an agrarian society, in which industry was just emerging. For instance, this figure is similar to the one found by Bennett et al. (2019) for

the UK between 1851-1911.

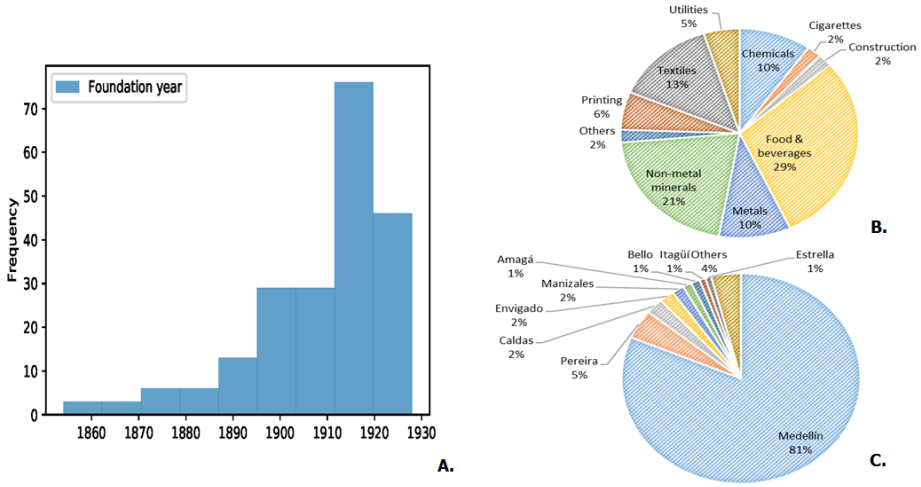
Figure A8: Attributes of the elite of Antioquia



Note: A. This figure presents the number of individuals in my sample by year of birth and death. B. This figure presents the distribution of economic activities performed by the individuals in the sample. Activities were not exclusive. C. This figure presents the distribution of cities of death of the individuals in my sample.

Also consistent with the historiographical evidence, the spatial distribution of the sample is largely concentrated in Medellín, which was the epicenter of the Antioqueña elite, followed by intermediate cities like Rionegro and Manizales (see Figure A9).

Figure A9: Attributes of industrial firms in Antioquia



Note: A. This figure presents the number of firms in my sample by year of foundation. B. This figure presents the distribution of economic activities performed by the firms in the sample. Activities were exclusive. C. This figure presents the distribution of locations of the firms in my sample at the city level.

1.3 Robustness checks

1.3.1 Extensive margin: to be or not to be an entrepreneur

Most of the regressions in this paper exploit what could be considered the *intensive margin decision*–i.e. the number of industries founded by an individual. However, you might also consider an *extensive margin decision*, in which the question is rather if individuals decided to become (or do not become) entrepreneurs. For capturing this latter margin, I explore the cross-individual data with a logistic model that estimates how the probability of creating at least one industrial firm relates to the position that individuals have in the social network.

Table A1 shows that the estimates for the extensive margin decision are equivalent in qualitative terms to those of the intensive margin decision (Table 5).

Table A1: Cross Section: Industrial Entrepreneurship and Social Networks. Logit

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
					Entrepreneurship					
Betweenness	0.193***		0.188***	0.170***	0.197***	0.178***	0.161**	0.187***	0.172***	0.131*
	(0.061)		(0.060)	(0.062)	(0.061)	(0.062)	(0.063)	(0.060)	(0.062)	(0.069)
Ego-density		0.205	0.143	0.143	0.154	0.078	0.126	0.140	0.167	0.114
		(0.200)	(0.205)	(0.207)	(0.207)	(0.211)	(0.202)	(0.205)	(0.206)	(0.211)
Banker				0.447*						0.220
				(0.237)						(0.261)
Immigrant					1.238*					0.168
					(0.722)					(0.807)
Engineer						0.868**				0.675
						(0.406)				(0.432)
Miner							1.264***			0.989***
							(0.334)			(0.359)
Politician								0.055		0.052
								(0.275)		(0.293)
Merchant									0.806***	0.751***
									(0.246)	(0.261)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	954	954	954	954	954	954	954	954	954	954

Note: This table establishes the statistically and economically significant correlation between industrial involvement and social networks after accounting for a set of basic controls and an extended set of confounders. The unit of observation is the individual. Industrial involvement is measured as having founded at least one industrial firm. Independent variables are standardized. Coefficients from columns 1- 10 are in log-odds units. Coefficients in column 10b are marginal effects. Robust standard error estimates are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

1.3.2 Alternative models

The outcome variable in most of my analyses is a counting variable, the number of firms created. Some argue that an OLS approach is not appropriate in such setting. In this section, I show that my results are robust to other conventional estimation methods.

The usual way of modeling count data is through a Poisson regression. However, as the descriptive statistics suggest, we are facing overdisperse data.[32] On the context of overdispersion, negative binomial regressions are frequently preferred.[33] Moreover, zero-inflated negative binomial models are commonly used if there is a large presence of zeros (Cameron and Trivedi, 2013).[34]

In any case, in the cross-sectional setting, the estimates from all these approaches offer quite similar results among them and with respect to the OLS estimates presented in Table 5.

[32]This concern is corroborated by a Pearson and Hosmer-Lemeshow goodness-of-fit test.

[33]A supportive evidence for choosing this model is that the likelihood-ratio test for the parameter alpha indicates that the negative binomial model outperforms the Poisson model for my data.

[34]A Vuong test suggests that a regular negative binomial regression outperforms a zero-inflated one.

Table A2: Cross section: Industrial Entrepreneurship and Social Networks

	(1a)	(1b)	(2a)	(2b)	(3a)	(3b)
	Entrepreneurship					
	Negative Binomial		Poisson		Z.I. Negative Binomial	
Betweenness	0.022***	0.017***	0.022***	0.017***	0.019**	0.016**
	(0.007)	(0.006)	(0.005)	(0.005)	(0.007)	(0.008)
Ego-density	0.108	0.096	0.106	0.115	0.080	0.099
	(0.227)	(0.203)	(0.222)	(0.236)	(0.212)	(0.211)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Confounders	-	Yes	-	Yes	-	Yes
Observations	954	954	954	954	954	954

Note: This table establishes the statistically and economically significant correlation between industrial involvement and social networks after accounting for a set of basic controls and an extended set of confounders. The unit of observation is the individual. Industrial involvement is measured as the number of firms founded by an individual during her lifetime. Independent variables are standardized. Coefficients are the difference in the logs of the expected number of industrial firms founded if the predictor would be one standard deviation above the mean, given the other predictor variables held constant. Robust standard error estimates are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Although, somewhat more challenging, when looking at the panel data, the basic alternative estimation methods also provide equivalent results to the OLS. The challenges here refer to the difficulties of nonlinear-fixed-effects models. Most of those come from the *incidental parameter problem* (see Fernández-Val and Weidner, 2016). In this context, authors such as Hilbe (2011) and Cameron and Trivedi (2013) prefer fixed-effects Poisson models with cluster standard errors to fixed-effects negative binomial regressions, even in situations of data overdispersion.

Table A3: Panel: Industrial Entrepreneurship and Social Networks

	(1a)	(1b)	(1a)	(2a)	(2b)	(2c)
	Entrepreneurship					
	Negative Binomial			Poisson		
Betweenness	0.129***		0.137***	0.137***		0.147***
	(0.026)		(0.026)	(0.0436)		(0.0481)
Ego-density		0.186**	0.220***		0.142	0.186
		(0.074)	(0.075)		(0.118)	(0.116)
Individual FEs	Yes	Yes	Yes	Yes	Yes	Yes
Number of decades	8	8	8	8	8	8
Observations	774	774	774	774	774	774
Number of groups	140	140	140	140	140	140

Note: This table establishes the statistically and economically significant correlation between industrial involvement and social networks after accounting for a set of basic controls and an extended set of confounders. The unit of observation is the individual. Industrial involvement is measured as the number of firms founded by an individual during her lifetime. Independent variables are standardized. Coefficients are the difference in the logs of the expected number of industrial firms founded if the predictor would be one standard deviation above the mean, given the other predictor variables held constant. Classical standard error estimates are reported in parentheses for columns 1. Robust standard error estimates are reported in parentheses for columns 2. *** p<0.01, ** p<0.05, * p<0.1.

This shows that the main results of this paper do not come from specificities in the estimation methods, but from more profound patterns in the data.

1.3.3 Measurement error

There is an extensive literature on the potential inference bias in sampled networks (Smith et al., 2017; Wagner et al., 2017; Smith and Moody, 2013; Wang et al., 2012; Huisman and Steglich, 2008; Kossinets, 2006; Borgatti et al., 2006; Costenbader and Valente, 2003). Every study in this literature explores some aspect of what seems to be an inherent conflict of sampled network data between the representativeness of nodes and that of edges. For instance, a random sample of nodes offers a completely representative sample of the population–i.e. the distritubion of nodes' attributes replicates the one of population's attributes–but destroys the network structure–i.e. the distritubions of structural metrics of the sampled network do not replicate the ones of the real network–because it ignores a set of nodes and ties that might be essential in the network connectivity. Meanwhile, several non-random sampling methodologies might be able to offer a good representation of the network structure but they imply some bias in the selection of nodes (Faugier and Sargeant, 1997). This conflict can be framed in a discussion proposed by Van Meter (1990) on the trade-off between the *ascending sampling method* and the *descending sampling method*. In his view, descending methods involve strategies elaborated at the level of general populations, allowing the configuration of a more representative sample. Meanwhile, ascending methods involve research strategies elaborated at local level and specifically adapted to the study of selected social groups, offering better defined networks.

My data-collection design considers the reflection of Van Meter (1990) by combining both descending and ascending methodologies–second and first components of the relational data respectively (see Section 3.2.1). This strategy does not solve completely the conflict between representativeness of nodes and edges. However, in this section I show that it alleviates every relevant concern of sampling-error bias that could be driven my main results.

Network-structure inaccuracy: Selection of edges This set of biases is related to a misleading representation of the real edges in the network.

You can expect the second component of my sampling to have errors in the recorded edges because it does not capture ties between social spheres. However, there is no reason to think that those errors are systematically related to the identity of each individual. Thus, in such a context of random measurement error, the concern would lead to an attenuation bias in my estimation. Therefore, coefficients in Table 5 must be interpreted as lower bounds of the real effects.

Most importantly, a similar kind of bias could exist in the first component of the data. In particular, the seeds of the snowball sample–i.e. the largest bankers in 1888–may introduce a bias by generating a structure in which sampled edges over-represent paths that go through

those seeds and their acquaintances. For the estimation of Table 5, this implies that those seeds would be better connected by construction. As the seeds have particular attributes–they were not randomly selected–the effect of their position in the network might be confounding the effect of their attributes.

I deal with this concern by estimating the regressions from Table 5 excluding the seeds and their immediate family. In addition, as the chain of nodes might have expanded particularly quickly among members of the banking system, I test the effects of excluding all the bankers at 1888, when the seeds were collected (see Table A8). The results are virtually the same in all three subsamples as well as compared with those of Table 5. This offers confidence that the main results of the paper are not being driven by a bias originated in the selection of the snowball-sample seeds.

Table A4: Panel: Industrial Entrepreneurship and Social Networks. Seeds-Exclusion Test. OLS

	(1)	(2)	(3)	(4)	(5)	(6)
	Entrepreneurship					
	No seeds		No seeds' family		No bankers 1888	
Betweenness	0.008**	0.006*	0.011**	0.008*	0.012***	0.009**
	(0.003)	(0.003)	(0.004)	(0.004)	(0.004)	(0.004)
Ego-density	0.036	0.011	0.009	-0.016	0.046	0.007
	(0.069)	(0.068)	(0.074)	(0.073)	(0.080)	(0.078)
Confounders	-	Yes	-	Yes	-	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	950	950	929	929	802	802

Note: This table establishes the statistically and economically significant correlation between industrial involvement and social networks after accounting for a set of basic controls and an extended set of confounders. The unit of observation is the individual. Industrial involvement is measured as the number of firms founded by an individual during her lifetime. Independent variables are standardized. Columns 1 and 2 exclude the four seeds. Columns 3 and 4 exclude sons, daughters, and wives of the seeds. Columns 5 and 6 exclude every banker in 1888. Coefficients are the difference in the logs of the expected number of industrial firms founded for one standard deviation increase in the predictor variable, given the other predictor variables held constant. Robust standard error estimates are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Another concern about selection of edges is that a certain type of bias exists in the archival information. For instance, it is feasible that historiography has a particular interest in industrial entrepreneurs, or that industrial firms had better recording methods that allowed a long-lasting preservation of their information. Any of those situations would have led to a more extensive amount of relational information about industrial entrepreneurs. In that case, the effects of network position may be confounding the effects of a data-collection bias.

For dealing with this concern I recorded the number of results on *Google.com* of several ways of spelling the names and capturing the identity of each of these individuals. Even though these measures are not completely accurate representations of the amount of information recorded for each individual, this method has been proved in several contexts (Seifter et al.,

2010; Choi and Varian, 2012) as appropriate for capturing real differences in popularity and interest across subjects, which is the origin of the bias concern I am referring to. Table A5 shows that including this sort of controls do not change the main results. Moreover, these controls are not significant and positively correlated with industrial involvement, suggesting that there is not even such a historiographical bias towards industrial entrepreneurs.

Table A5: Panel: Industrial Entrepreneurship and Social Networks. Historiography-Bias Test. OLS

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Entrepreneurship							
Betweenness	0.092**	0.071**	0.092**	0.071**	0.090**	0.069*	0.090**	0.069*
	(0.038)	(0.036)	(0.038)	(0.036)	(0.038)	(0.036)	(0.038)	(0.036)
Ego-density	0.003	-0.021	0.002	-0.022	0.004	-0.021	0.003	-0.022
	(0.074)	(0.073)	(0.074)	(0.073)	(0.075)	(0.073)	(0.075)	(0.073)
GoogleI	-2.907*	-2.318*						
	(1.625)	(1.297)						
GoogleII			-0.566***	-0.459**				
			(0.211)	(0.182)				
GoogleIII					0.089	0.110		
					(0.099)	(0.103)		
GoogleIV							0.110	0.140
							(0.110)	(0.115)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Confounders	-	Yes	-	Yes	-	Yes	-	Yes
Observations	954	954	954	954	954	954	954	954

Note: This table establishes the statistically and economically significant correlation between industrial involvement and social networks after accounting for a set of basic controls and an extended set of confounders. The unit of observation is the individual. Entrepreneurship is measured as the number of industrial firms founded by an individual during her lifetime. Independent variables are standardized. Googles variables refer to the number of results in Google.com with different keywords. GoogleI refers to the bare name and surnames (e.g. "Antonio José Álvarez Carrasquilla"). GoogleII refers to the bare name and surname and the word Antioquia (e.g. "Antonio José Álvarez Carrasquilla" Antioquia). GoogleIII refers to the bare name and surname and the words Antioquia Siglo XIX (e.g. Antonio José Álvarez Carrasquilla Antioquia Siglo XIX). GoogleIV refers to the bare name and surname and the words Antioquia Siglo XX (e.g. Antonio José Álvarez Carrasquilla Antioquia Siglo XX). Heteroskedasticity robust standard error estimates are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Sample representativeness: Selection of nodes There is another set of concerns that relates to the inclusion/omission of nodes with certain particular features. As it is usual in snowball sampling (see Biernacki and Waldorf, 1981), individuals with more visible positions in the network were potentially more likely, than isolated ones, to be included in the first component of my sample. If the relation between industrial involvement and betweeness centrality was not monotonous, or if isolated nodes–i.e. those that are missing in the sample– presented a different behavior than non-isolated ones–i.e. those that are in the sample, the results of Table 5 might have been biased.

The literature uses three strategies to minimized this potential bias.

First, as Van Meter (1990) and Atkinson and Flint (2001) show, a large sample size reduces this type of bias. My sample is fairly large. To offer an idea of this, consider that annual interest rates in the last decades of the 19th century were about 9%. Then, a capital of 3,250 pesos would have represented an annual income of 292.5 pesos. Based on the single wealth

census available for the 19th century (Robinson and García-Jimeno, 2010), in 1851 only 309 people in Antioquia had a capital income - including land rent- above 292.5 pesos. Assuming that income distribution and capital/labor share did not change, and following the population estimates of (Mejía, 2015a), by 1905, only 422 people would have earned more than 292.5 pesos from capital income. This figure represents the 68% of working-age individuals in my sample measured in the year 1905. This implies that my sample includes more than the individuals wealthy enough to have been an average industrial entrepreneur.

Second, authors like Faugier and Sargeant (1997) emphasize the importance of using several seeds as unrelated as possible in the snowball sampling. This increases the likelihood of reaching isolated individuals. My design follows this suggestion, using four different seeds, all of whom belonged to different families. Table A6 shows the shortest path distance among the seeds. In spite of being closer than two random individuals in average in the sample (the average distance is 4.8), none of these seeds were in direct connection with each other, and in certain situations were fairly far away. For instance, seeds A and B were four steps from each other, which is a considerable number if we have in mind that they were contemporary.

Table A6: Distance matrix. Complete network. Snowball seeds

	Seed A	**Seed B**	**Seed C**	**Seed D**
Seed A	0			
Seed B	2	0		
Seed C	3	2	0	
Seed D	4	2	2	0

Note: This table presents the distance matrix of snowball seeds in the complete network.

Third, the second component of the sample is a descendant methodology, free of the link-tracing concerns of the snowball sample. This component allows me to reach those isolated individuals unlikely reachable by the snowball sampling. Table A7 shows that the individuals from the first and second component of the sample differ in the expected ways. The second component's individuals have on average lower betweenness centrality, as it is a more fragmented network. They are also less involve in industrial entrepreneurship. However, that difference is not statistically significant.

Table A7: Comparisons of the components of the sample

	Second component	**First component**	**Difference**
Industrial	0.11	0.12	-0.01
Entrepreneurship	0.19	0.21	-0.02
Betweenness	0.3	6.84	-6.54***
Ego-density	17.91	16.44	1.46**

Note: This table presents the mean of the independent variables of interest (i.e. Betweenness centrality and ego-density) and the dependent variables (i.e. industrial involvement in its discrete and counting version) by components of the sample. The second component excludes individuals who are uniquely connected through banking ties. *** p<0.01, ** p<0.05, * p<0.1.

Moreover, including these isolated individuals in the regression, if anything, increases the coefficient sizes. Thus, using the nodes resulted from the first component of the sample does not seem to be biasing the results as a result of excluding isolated nodes.

Table A8: Cross section: Industrial Entrepreneurship and Social Networks. OLS. Sample Bias Test

	First component	Full Sample
	Entrepreneurship	
Betweenness	0.085**	0.095***
	(0.038)	(0.035)
Ego-density	-0.031	0.005
	(0.022)	(0.018)
Male	0.239***	0.239***
	(0.030)	(0.025)
Observations	954	1,352

Note: This table establishes the statistically and economically significant correlation between industrial involvement and social networks. The unit of observation is the individual. Industrial involvement is measured as the number of firms founded by an individual during her lifetime. Betweenness centrality and Ego-density are standardized. Full sample includes First and Second components. Second component excludes individuals who are uniquely connected by banking ties.

1.3.4 Reverse causality: persistence in time

It is natural to expect some feedback between the position of an individual in the social network and her entrepreneurial decisions.[35] Hence, the results from tables 5 and 6 might reflect either the effect of global connectivity on entrepreneurship or the effect of entrepreneurship on global connectivity. To disentangle this issue, I exploit time variation and take lags of the predictors (i.e. network metrics) keeping the outcome (i.e. industrial involvement) in time t. Thus, I offer an specification free of the reverse causality concern mentioned above. As current entrepreneurship cannot explain past social interactions, any significant correlation in this new specification must come from social networks to entrepreneurship and not the other way around.

[35] Authors like Lee (2010) show that brokerage positions are determined by previous individual performance.

Table A9: Panel: Industrial Entrepreneurship and Social Networks. OLS. Reverse Causality Test

	Entrepreneurship							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Betweenness	0.092***	0.060***						
	(0.024)	(0.023)						
Ego-density	0.000	-0.038**						
	(0.014)	(0.016)						
Betweenness T-1			0.030**	0.020**				
			(0.013)	(0.010)				
Ego-density T-1			-0.016	-0.028**				
			(0.013)	(0.013)				
Betweenness T-2					-0.001	-0.001		
					(0.012)	(0.012)		
Ego-density T-2					-0.019	-0.021		
					(0.018)	(0.018)		
Betweenness T-3							-0.021	-0.018
							(0.016)	(0.016)
Ego-density T-3							-0.035	-0.029
							(0.025)	(0.025)
Individual FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Network Controls	-	Yes	-	Yes	-	Yes	-	Yes
Number of Periods	8	8	7	7	6	6	5	5
Observations	11,256	11,256	9,893	9,893	8,393	8,393	6,776	6,776
Number of individuals	1,806	1,806	1,806	1,806	1,806	1,806	1,806	1,806

Note: This table establishes the statistically and economically significant correlation between industrial involvement and social networks. The unit of observation is individual-decade. The sample period is 1850-1930. Industrial involvement is measured as the number of firms founded by an individual until the considered decade. Independent variables are standardized. Coefficients are the difference in the logs of the expected number of industrial firms founded if the predictor would be one standard deviation above the mean, given the other predictor variables held constant. Classical standard error estimates in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Indeed, Table A9 shows that betweenness centrality at period $t-1$ is positive and significantly correlated with industrial involvement at period t. The magnitude of the lagged coefficient is smaller. This might point out that the contemporary regressions do capture an effect from entrepreneurship to social networks. It could also be a sign of a decay in the effectiveness of social networks over time. Contacts that existed a decade ago might not be as useful as current contacts. This is consistent with the fact that two-decades-lagged levels of global connectivity do not significantly correlate with entrepreneurship.

In any case, Table A9 shows that the positive correlation between entrepreneurship and global connectivity found in tables 5 and 6 cannot be exclusively interpreted as a result of individuals that got involved first in industrial activities and, then, saw their connectivity improved.

1.3.5 Selection of delta individuals

The fundamental assumption in the identification strategy of Section 4.3 is that the death of the delta individuals was unexpected. The selection itself of the delta individuals precisely guarantees that. A person was a delta individual if there was a significant indication, in any

of the sources, that her death was unexpected. In most cases, this was an explicit mention to the circumstances in which the death took place. An assassination, an accident or an illness at a young age are examples of this. An examples of this was the death of José María Amador (see Figure A7). In a few cases, the indication was more subtle, such as death at young age after a recent marriage (see Table A10 for details).

Table A10: Delta Individuals

Name	Decade of death	Age at death	Cause of death
Manuel Echeverri Bermúdez	1850	28	Unknown
Inés Pérez Lalinde	1860	20	Unknown
Pascual Bravo Echeverri	1860	28	Assesinated
Mauricio Uribe Santamaría	1870	46	Unknown disease
Uladislao Vásquez Jaramillo	1870	43	Assesinated
Víctor Restrepo Maya	1870	43	Died in an accident
Antonio José Santamaría ángel	1870	23	Assesinated
Isabel Pérez Lalinde	1880	29	Unknown
Julián Vásquez Jaramillo	1880	40	Unknown
José María Amador Uribe	1890	24	Tuberculosis
Claudina Villa Muñoz	1890	56	Unknown
Santiago Ospin a Vásquez	1900	48	Unknown disease
Ana Echavarría Echavarría	1910	31	Unknown

Note: This table list the attributes of the delta individuals.

In order to show that there is no particular bias in the selection of the delta individuals, I present a balance test in Table A11. This shows that that delta individuals, on average, were not statistically different than the rest of the sample except for their earlier death.

Table A11: Balance test. Non-delta population vs delta population

	Non-delta population	Delta population
Age at death	69.23***	35.3***
	(11.75)	(11.26)
Male	0.76	0.69
	(0.009)	(0.133)
Wealth 1850	1.41	1.61
	(1.38)	(1.11)
Mining	0.079	0.153
	(0.27)	(0.375)
Merchant	0.214	0.384
	(0.41)	(0.506)
Liberal	0.09	0.153
	(0.375)	(0.286)
Foreign ancestry	0.024	0.076
	(0.153)	(0.277)
Ego-density	26.4	14
	(36)	(11.2)
Betweenness	71	140
	(176)	(91)
Creation of firms	0.152	0.076
	(0.621)	(0.277)
Observations	955	13

Note: This table presents the means of different variables for the delta individuals and the rest of the population. Standard deviation in parentheses. Stars define the significance of t-test. *** p<0.01, ** p<0.05, * p<0.1.

Finally, my confidence on the validity of the quasi-experiment are reassure by the fact that

its results are not sensitive to the selection of any delta individual in particular. Table A12 replicates specification (4) of Table 7 excluding one shock at a time–i.e. in one period, the synthetic network does not consider the disappearance of one delta individual. The results of A12 and Table 7 are practically the same.

Table A12: Quasi-experiment: Industrial Entrepreneurship and Social Networks. Sensitivity to shock composition. OLS

	Entrepreneurship				
	(¬Manuel E.)	(¬Ines P.)	(¬Pascual B.)	(¬Mauricio U.)	(¬Uladislao V.)
Change Betweenness	0.013*	0.013*	0.013*	0.014*	0.013*
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
	(¬Victor R.)	(¬Antonio Jose S.)	(¬ Isabel P.)	(¬Julian V.)	(¬Jose Maria A.)
Change Betweenness	0.013*	0.013*	0.013*	0.014*	0.013*
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
	(¬Claudina V.)	(¬Santiago O.)	(¬Ana E.)		
Change Betweenness	0.013*	0.013*	0.013*		
	(0.007)	(0.007)	(0.007)		
Individual FEs	Yes	Yes	Yes	Yes	Yes
Ego-density Control	Yes	Yes	Yes	Yes	Yes
Time FEs	Yes	Yes	Yes	Yes	Yes
Network Controls	Yes	Yes	Yes	Yes	Yes
Number of Periods	8	8	8	8	8
Observations	11,242	11,242	11,242	11,242	11,242
Number of individuals	1,805	1,805	1,805	1,805	1,805

Note: This table establishes the statistically and economically significant correlation between industrial involvement and social networks. The unit of observation is individual-decade. The sample period is 1850-1930. Each specification represent the same regression without considering the dissaperance Entrepreneurship is measured as the number of firms founded by an individual during the considered decade. Robust standard error estimates in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

1.3.6 Placebo tests

Exogenous shocks validity To indicate that change in the levels of entrepreneurship that come with the disappearance of the delta individuals is not an weird artifact, I provide a placebo test. This test consists of checking if the disappearance of delta individuals generated any change in levels of entrepreneurship in the past. The results of this test are presented in Table A13

Table A13: Placebo quasi-experiment: Industrial Entrepreneurship and Social Networks. OLS

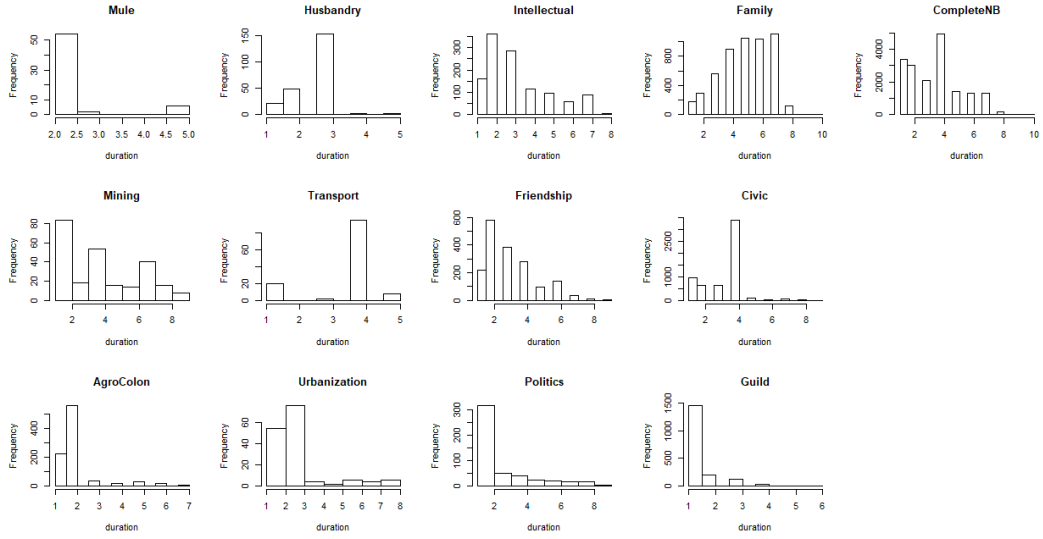
	Past Entrepreneurship			
	(1)	(2)	(3)	(4)
Change Betweenness	-0.028	-0.000	0.001	0.003
	(0.035)	(0.034)	(0.034)	(0.033)
Individual FEs	Yes	Yes	Yes	Yes
Ego-density Control	-	Yes	Yes	Yes
Time FEs	-	-	Yes	Yes
Network Controls	-	-	-	Yes
Number of Periods	8	8	8	8
Observations	11,241	11,241	11,241	11,241
Number of individuals	1,805	1,805	1,805	1,805

Note: This table establishes the statistically and economically non-significant correlation between past entrepreneurship and contemporaneous change in betweenness centrality. The unit of observation is individual-decade. The sample period is 1850-1930. Entrepreneurship is measured as the number of firms founded by an individual during the considered decade. Robust standard error estimates in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

As expected, Table A13 shows that changes in the global connectivity resulted from the death of delta individuals are not correlated with variations on the levels of entrepreneurship before the shocks happened.

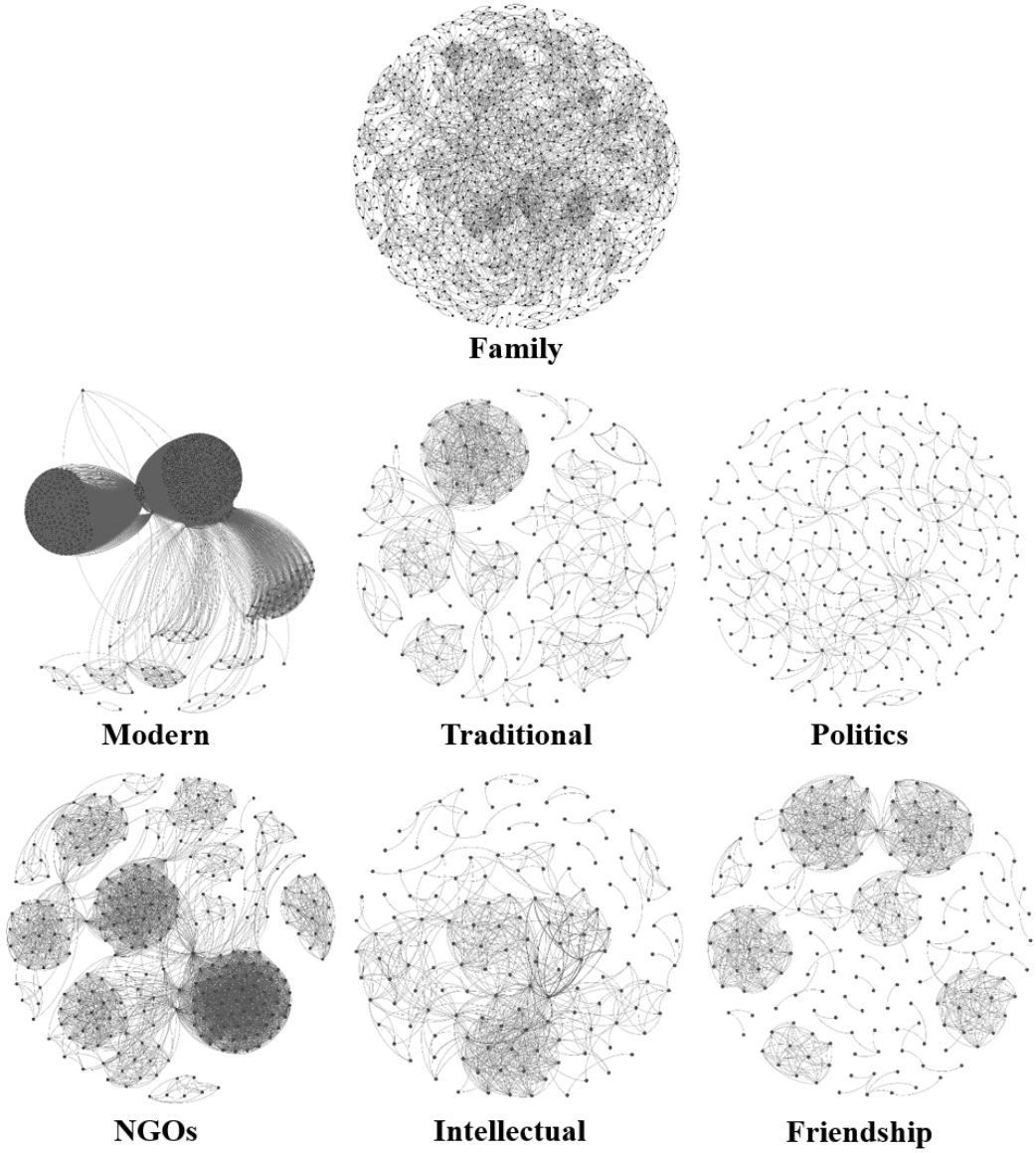
1.4 Network graphs and additional figures

Figure A10: Edge Duration by Type of Interaction. Histogram



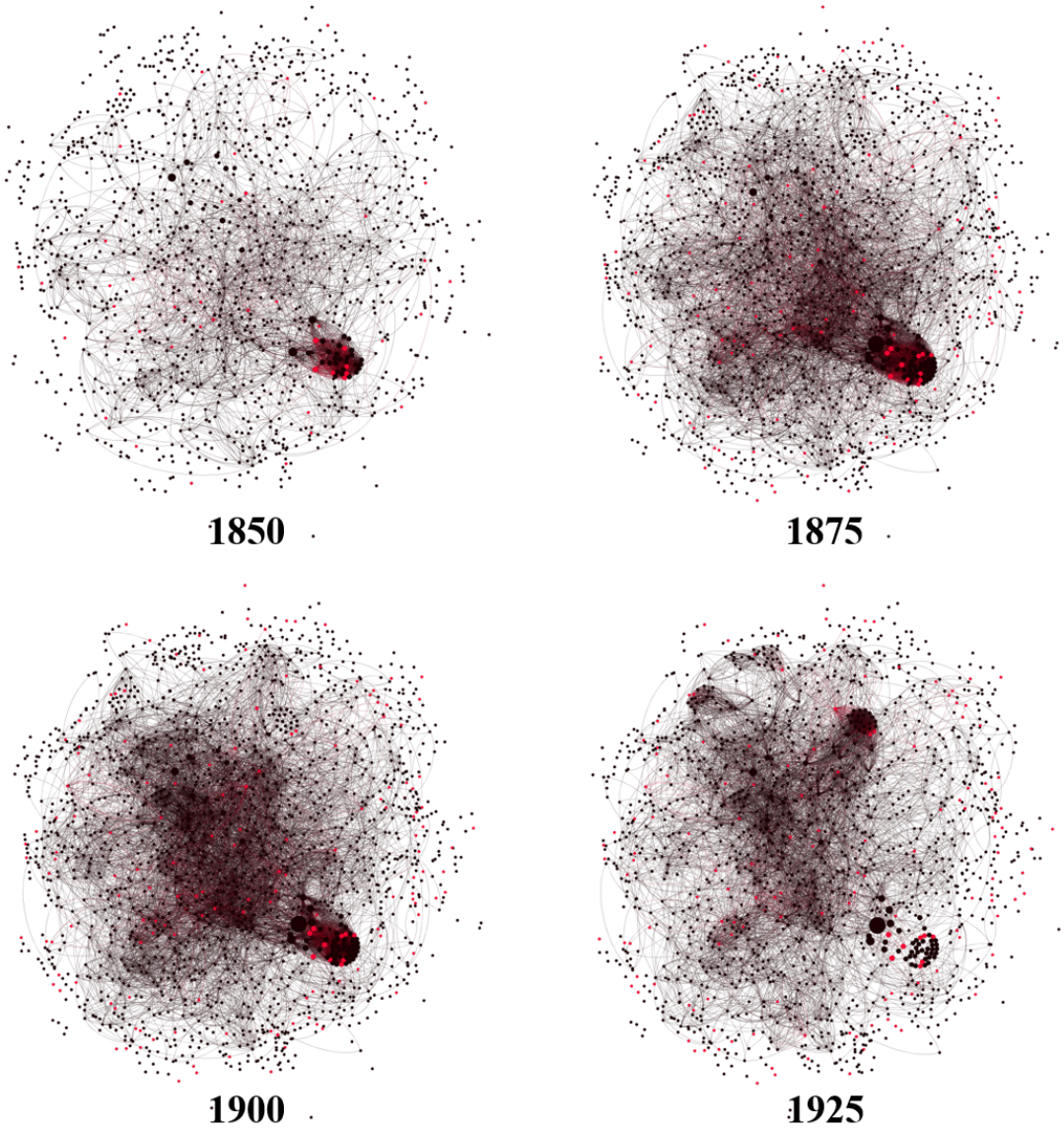
Note: Each graph in this figure presents the number of edges by duration (i.e. the number decades that edges are active) for a particular type of interaction. An edge is born once an interaction between two nodes is identified. An edge disappears if there is information about the destruction of the interaction, or if one of the nodes that compose the interaction dies.

Figure A11: Static Networks



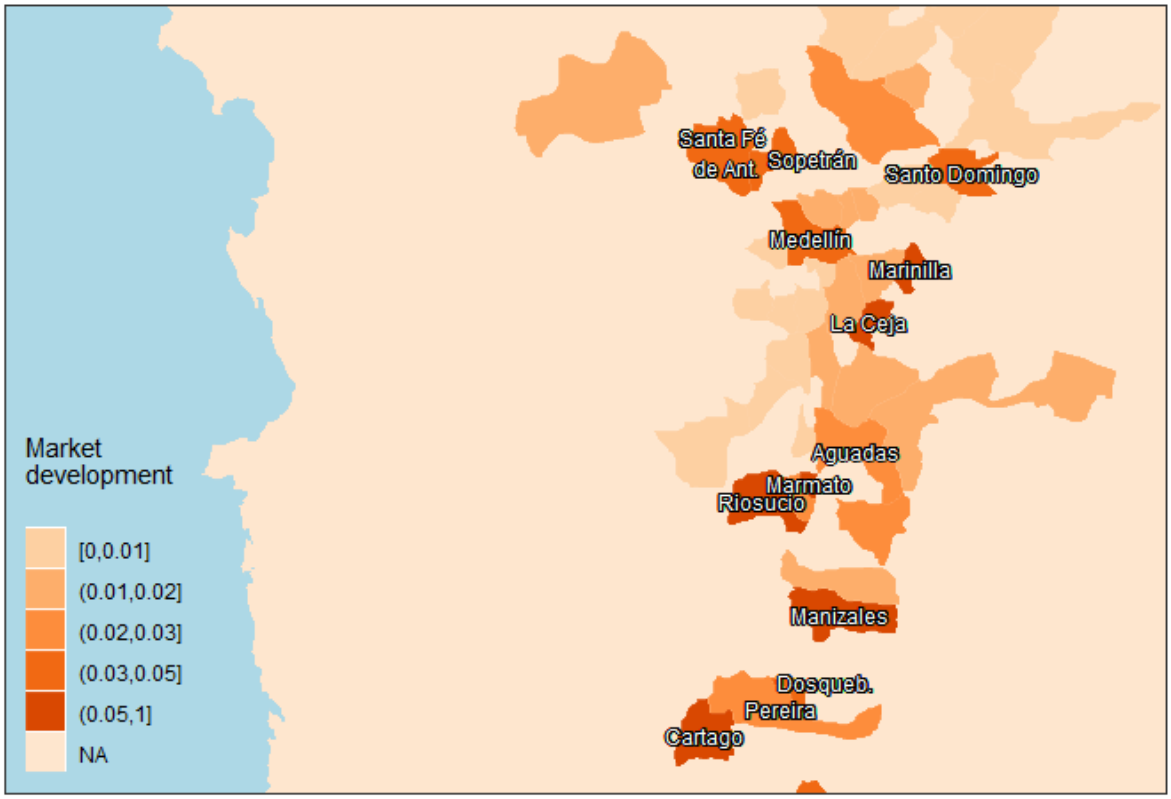
Note: This figure presents the graph of each static network. Dots represent individuals (i.e. nodes) and lines represent interactions between them (i.e. edges). Nodes and edges have the same shape.

Figure A12: Complete Network in Time



Note: This figure presents the graph of the complete network in four instants: 1850, 1875, 1900, 1925. Dots represent individuals (i.e. nodes) and lines represent interactions between them (i.e. edges). Red nodes are industrial entrepreneurs. The size of nodes is proportional to their degree.

Figure A13: Market development. Antioquia. 1912



Note: This figure presents the map of study with the current frontiers of municipalities. I measure market development as the ratio of the number of *empleados* over the number of *jornaleros* for municipalities in 1912 Census. Empleados were wage workers, mostly located in urban activities. They operated in a fairly similar way to any current office job. Instead, a jornalero was a worker hired by a traditional labor relation, closely tied to ancestral serfdom institutions. Jornaleros were mostly agricultural workers payed by the day. Frequently, they were payed with production (Bejarano, 1998). Therefore, the ratio of this two types of labor is a scale-free proxy of the relative importance of markets in the economy.