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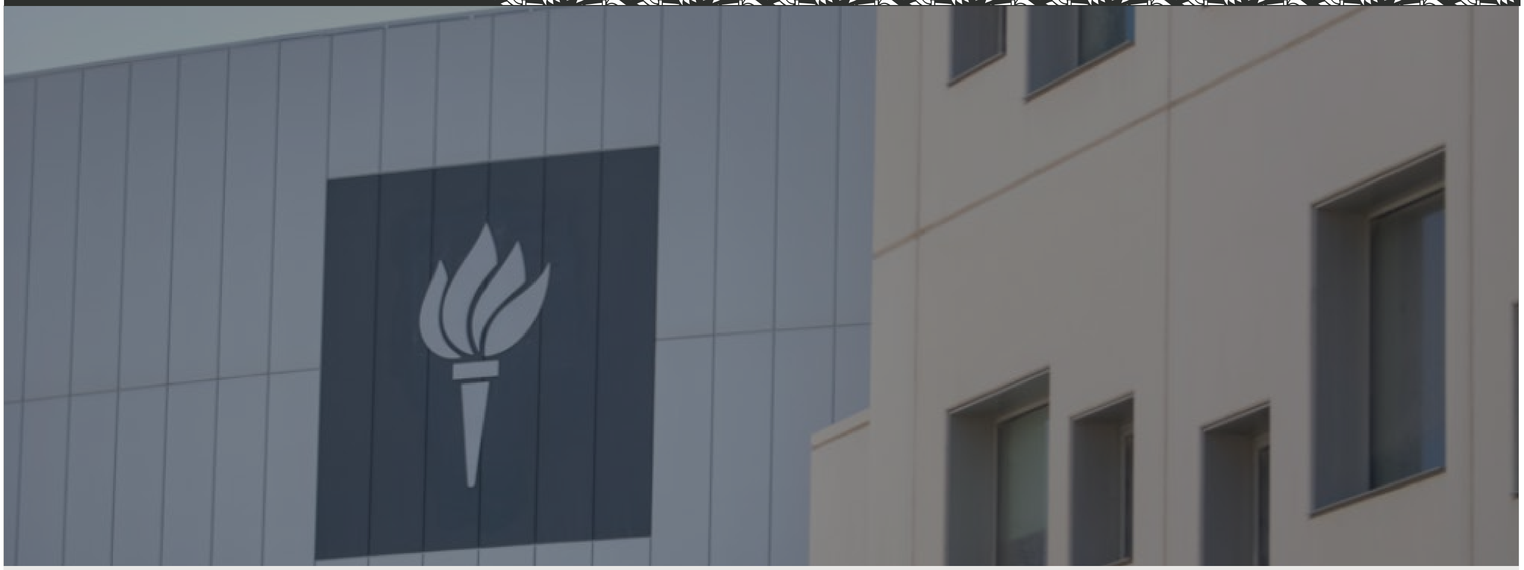

Social Networks and Entrepreneurship. Evidence from a Historical Episode of Industrialization

Javier Mejia

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Social Networks and Entrepreneurship. Evidence from a Historical Episode of Industrialization

Javier Mejia[*][†]

New York University Abu Dhabi

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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, characterized by difficult geographical conditions, market failures, and weak state capacity, as in late 19th- and early 20th-century Antioquia (Colombia). With these data, I estimate how the decision to found industrial firms related to the position of individuals in the social network. I find that individuals more important bridging the network (i.e. with higher betweenness centrality) were more involved in industrial entrepreneurship. However, I do not find individuals with a denser network to be more involved in this type of activity. The rationale of these results is that industrial entrepreneurship was a highly-complex activity that required a wide variety of complementary resources. Networks operated as substitutes for markets in the acquisition of these resources. Thus, individuals with network positions that favored the combination of a broad set of resources had a comparative advantage in industrial entrepreneurship. I run several tests to prove this rationale.

JEL Classification: O1, L1, L2, N8.

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[†] Email: javiermejia@nyu.edu/mejiaja20@gmail.com. Website: http://javiermejia.strikingly.com/

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)[2]. Therefore, a better understanding of entrepreneurship is fundamental for both intellectual and practical reasons.

Nevertheless the importance of entrepreneurship, we know very little about its social determinants. In particular, we ignore how the social-interaction patterns of individuals relate to their decision to involve in entrepreneurship. For instance, certain type of network positions have been related to risk sharing and knowledge acquisition, among other productive advantages (see Chandrasekhar et al., 2014; Breza et al., 2015; Conley and Udry, 2010; Banerjee et al., 2013; Miller and Mobarak, 2014). Hence, we might expect entrepreneurs to be in those kinds of network positions with a higher probability than non-entrepreneurs. However, there are no studies testing empirically this type of hypotheses.

This paper fills that gap, exploring how the position of an individual in her social network relates to her decision of becoming an entrepreneur–i.e. founding a firm in a new and risky sector. The evidence comes from a historical episode in which members of an elite decided to invest in industry, which was an activity completely unknown for them and implied large investments and uncertainty.

To be specific, I reconstruct the social network of the elite of Antioquia (a Colombian region) in the late 19th and early 20th century–at a time when industry was just starting to emerge. I use discrete choice models to estimate how the decision to found industrial firms was 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 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 close to what currently some literature call *transformational entrepreneurship*, or *gazelles/high-growing firms' entrepreneurship*. This is the kind of entrepreneurship that drives the majority of innovation, wealth creation, and new job generation (see Schoar, 2010; Colombelli et al., 2013; Nightingale and Coad, 2013; Bos and Stam, 2013; Daunfeldt et al., 2015)

[2]For an overview of the promotion of entrepreneurship as a development policy see Lora and Castellani (2013), for Latin America; Edoho and Edoho (2016), for Africa; and Bruton et al. (2015), for Asia.

The paper has two main results. On the one hand, I find a positive relationship between industrial involvement and betweenness centrality. Concretely, an increase in one standard deviation in betweenness centrality was associated with a 16.6% additional firms founded with regard to the mean. This relation is robust to different types of estimation methods, to the inclusion of every reasonable control, and, in general, to every classical endogeneity concern. On the other hand, I do not find a robust relationship between ego-density and industrial involvement.

The rationale of these results is that industrial entrepreneurship was a highly complex activity that required a wide variety of complementary resources. Networks operated as substitutes of markets in the acquisition of these resources. Thus, individuals with network positions that favored the access to a broader set of resources–i.e. with higher betweenness centrality–had a comparative advantage in industrial activities. Meanwhile, having a supportive social circle did not guarantee access to all the required resources. I collect and exploit complementary historical sources to offer evidence supporting this rational.

In a field like social networks, where data constraints are a primary concern (Breza et al., 2017), I innovate by exploiting the advantages of historical sources to provide detailed information in natural environments. The dataset constructed for this paper follows individuals over their entire lives, identifying their family, friendship, politics, business, intellectual, and civil activity ties. In addition, it includes information about all their entrepreneurial projects. This historiographic research 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. In that sense, this paper contributes in methodological terms to the literature in the intersection between economic history and development economics. Moreover, this allows me to improve the knowledge in social networks and development by shedding light on how the structure of an individual's global network relates to her entrepreneurial decisions, something hitherto unknown.

The paper is organized as follows: Section 2 goes into detail on the paper's contribution in light of different groups of literature. Section 3 presents the conceptual framework that describes how network structure is expected to affect entrepreneurial behavior. This section introduces, in particular, the concepts of closure and structural holes. In Section 4 I present the context of the case study, the data and the empirical strategy, which intends to measure the effects of closure and structural holes' measures in industrial entrepreneurship. Results are presented in Section 5; and Section 6 dispels every major endogeneity concern. Section 7 presents the mechanisms, while Section 8 offers some concluding remarks by contextualizing the results in the research agendas of development economics and economic history.

2 Related Literature

The case study shares the most fundamental attributes of current developing environments–e.g. difficult geographical conditions, market failures, and weak state capacity. In that sense, this paper dialogs directly to an increasing literature in development economics on the relationship between social networks and entrepreneurship. Works like Fafchamps and Quinn (2016); Cai and Szeidl (2016); Chatterji et al. (2017) have shown through randomized control trials in Africa, China, and India significant effects of improving the connectivity of firms and individuals in their entrepreneurial practices and performances. Despite the significant advances of this literature–mostly related to the virtues of experimental approaches–it has focused on a rather simplistic interpretation of social interactions. Three elements characterize the shortcomings of this literature: *(i)* restrictions to reconstruct extensively the real social network of entrepreneurs, *(ii)* restrictions to capture long-term outcomes, *(iii)* an emphasis on peer effects that ignores most of the broader impact of network structure[3]. Elements *(i)* and *(ii)* are empirical issues originated in the huge difficulties of network-data collection (see Breza, 2016; Breza et al., 2017). Element *(iii)* is rather a conceptual inheritance from what might be the most successful branch of social interactions in economics: the diffusion and peer-effects literature (see Manski, 2000; Blume et al., 2015). Let me describe these three elements in more detail.

Element *(i)* comes from the fact that most studies capture their relational data in intervened environments, which expectedly differ quite significantly from environemnts where real social networks are formed. Moreover, they are only capable to record formal interactions. For example, Cai and Szeidl (2016) use monthly self-organized meetings over a year among 1,480 managers. Chatterji et al. (2017) use a two-days retreat of 100 growing firms' founders. Meanwhile, Fafchamps and Quinn (2016) exploit common participation of about 700 managers into judging committees of an entrepreneurial competition. Some of these studies follow social interactions after the intervention, using the existence and intensity of meetings, calls, or emails of professional nature for defining the edges that compose the network. This approach brings two problems. On the one hand, it misses certain type of ties, in particular, those developed in non-professional environments (e.g. friendship and family), which related fields have shown as primordial in entrepreneurial activity (Renzulli et al., 2000; Anderson et al., 2005; Arregle et al., 2015)[4]. On the other hand, this approach might represent inaccurately the

[3]There is a long tradition in economic sociology and organizational studies that explores the interaction between social networks and entrepreneurship (see Zimmer, 1986; Renzulli et al., 2000; Greve and Salaff, 2003; Anderson et al., 2005; Street and Cameron, 2007). Even though this tradition uses different approaches, it shares with the economics literature elements *(i)* and *(ii)*.

[4]The rational of these findings is that non-professional ties are usually stronger and allow the transmission of highly valuable resources (e.g. high amounts of capital, highly productive ideas, and intense emotional

attributes of the interactions that they identify. This, because the content of the interaction is unknown.[5]

Element *(ii)* points out how this literature focuses on short-term outcomes, usually measured a couple of months after the intervention. Variables like sales, profits, and management practices with regard to clients, suppliers, and workers are some of the outcomes that the literature analyzes. Even though these are essential aspects for understanding entrepreneurship (see Bloom and Van Reenen, 2011; Bloom et al., 2013), the comprehension of long-term decisions, like the sector in which to operate, or the number of firms in which to invest, are also important and they are completely missing in this literature.

Element *(iii)* highlights how this literature uses as main theoretical framework the idea that resources and behaviors spill over the network. In that framework, the only role that network structure plays is to define how "infections" diffuse along the network, and, for individual matters, how likely it is that a particular node gets infected conditional to her distance to the focus of infection. In other words, the null hypothesis in this literature is that an individual connected with someone that has a particular attribute will adopt some of that attribute. Moreover, this adoption-rate/peer-effect is expected to decay with the distance of the connection.

Despite the great advantages of this framework, it ignores that social interactions also condition behavior in several other ways that the network structure allows to capture. For instance, the idea that individuals that bridge different components of the network have exceptional power to control the transmission of information (see Stovel and Shaw, 2012; Burt et al., 2013) is not part of the peer-effects mindset, but it certainly is a relevant aspect to consider.

Therefore, in this paper, I address these three issues taking advantage of archival records[6], which enable me to construct a social network that includes a comprehensive set of interactions occurred in non-intervened environments. My network captures family, friendship, politics, business, intellectual, and civil activities ties. Moreover, thanks to archival records I can also capture the long-term dynamic of the network, covering almost 150 years–an attribute that I use as core feature of the identification strategy, and that allows me to explore the persistence of the phenomenon. I can capture long-term outcomes as well. In particular, I record the information of all the industrial firms created in the region, identifying their founders and linking that information to the relation dataset.

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support).

[5]Consider frequent exchanges of emails. They might be capturing, for instance, conflicts of interest rather than transmission of ideas or advises.

[6]Archival records offer the empirical advantages for dealing with elements *(i)* and *(ii)*. Section 3 explains how I deal with Element *(iii)*

Thus, this paper contributes in a tangential way to other groups of literature. First, the broader literature on the effects of social networks on individual performance (see Munshi, 2003; Costa and Kahn, 2007; Beaman, 2012; Burchardi and Hassan, 2013; Schmutte, 2014; Costa et al., 2016) uses relational data that restricts to mutually exclusive and symmetric group memberships (i.e. classroom, caste, ethnicity, etc.). In that sense, they do not exploit thoroughly the information contained in social interactions, limiting to peer-effects analysis–they suffer from elements *(i)* and *(iii)*. Therefore, this literature will benefit from understanding how the precise position of individuals in the global network affects an activity with lifelong economic effects such as entrepreneurship, as I do in this paper.

Second, there is a long tradition that studies the role of social capital on economic growth (e.g. Annen, 2003; Ahlerup et al., 2009; Boulila et al., 2008; Francois and Zabojnik, 2005; Knack and Keefer, 1997; Lindner and Strulik, 2014; Tabellini, 2010; Zak and Knack, 2001.). 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[7]. I contribute to this research line by offering a more rigorous empirical exercise (I study a larger period of time, with a larger number of observations, and a more careful econometric strategy); focusing on individual decisions (I do not agglomerate my data into families or economic groups); and considering a more complex idea of social interactions (I explore a broader number of interactions and their conjunct behavior).

Third, this paper is important to the Colombian economic history literature (Ospina, 1955; McGreevey, 1971; Ocampo, 1988; Acemoglu et al., 2012; Espana and Sanchez, 2012); a deeper look in the determinants of the industrialization of Antioquia will clarify the transition to modern capitalism in the country [8].

[7]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 long-distance trade existed in the 11th-century Mediterranean, where formal mechanisms for enforcing contracts did not exist.

[8]In addition, in an even more tangential way, a social network analysis of the emergence of the first Colombian corporations would shed light on the origins of the current configuration of the entrepreneurial elite in the country, which is characterized by cross-shares, board interlocks and familiar links (Pombo et al., 2009; Gutiérrez and Pombo, 2009; González et al., 2012); aspects that, by the way, are also related to long-term stagnation of Latin-American nations (Lipset et al., 1967; Hirschman, 1958).

3 The Role of Network Structure

Even though peer-effects studies are the dominant approach in development and entrepreneurial research when it refers to networks (Bloom et al., 2016; Fafchamps and Söderbom, 2013), there is a branch of the field that is moving towards a more complex interpretation of the influence of social interactions on economic behavior, considering graph and community level characteristics (see Breza, 2016). A common place in the search for inspiration in this particular branch is the literature on social capital from sociology, which emphasizes how the structure of social networks interacts with individual behaviors and generates competitive advantages in different dimensions, depending on the context and the content of the interactions. 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. My empirical strategy is inspired by this literature.

3.1 Network Closure

A network with complete closure is one in which everyone is connected in such a way that no one can escape the notice of others. Closure is measured with the density of the ego-network[9], that is, the probability that any two connections of an individual are connected among them[10]. Denser networks–i.e. in which a larger fraction of network members are connected directly between them–are networks with higher closure.

An individual embedded in a network with high closure might benefit from it in two ways. First, members of a network with high closure should have a more accurate understanding of what is happening in their networks–if compared with a less high-closure network. This, because the quality of information deteriorates as it moves from one person to the next in a chain of intermediaries (Baker, 1984; Baker and Iyer, 1992). Therefore, increasing the network members connected directly among them reduce the steps required for making everyone aware of a particular unit of information and improves the quality of the information. Moreover, as new information will reach every member of the network faster; in average, individuals in a high closure network should be more efficient adapting to changing environments. For entrepreneurs, this implies that once certain information gets to any member of a network–ex. a new regulation, an unexpected change in supply prices, etc.–it will disperse more quickly and

[9] 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.

[10] 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 11.1 for details on the construction of the measure)

accurately in the whole network 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 through which an individual might benefit from a high-closure network is that it facilitates sanctions, reducing uncertainty and making easier for people to trust one another (Burt, 2000). This fact reduces transaction costs and generates incentives to develop productive activities–in particular those with higher uncertainty, and those that face a larger threat of free riding behavior.

To understand the rationale of this mechanism consider a stable one-component network with the lowest closure possible, a star, for instance. In a star there is only one node that interacts with the rest. In such a network, the collective sanctions that would ensure trustworthiness cannot be applied, simply because people do not have frequent interactions. First, as everyone except for the center of the star do no share information, it would be unlikely that any enforcement mechanism–either bilateral or multilateral–could take place. In contrast, in a network with high closure, a large set of frequent interactions among the different members of the network offer the opportunity to inform misconducts and enforce punishments in posterior interactions.

This mechanism was popularized by Putnam et al. (1994) and Fukuyama (2002), and has captured the attention of almost every social capital study in economics. Theoretical foundations for these ideas have come from authors like Raub and Weesie (1990), Lippert and Spagnolo (2011), Jackson et al. (2012), and Ali and Miller (2013). They prove in different types of network games that cooperation and prosocial behavior can be sustained by certain forms of high-closure structures.

3.2 Structural Holes

Bridging a structural hole–brokerage, as it is know–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 general idea is that these subnetworks have different types of resources (including information), precisely because they are isolated from each other and, therefore, have not been able to share their "original" resources. Thus, to broker these subnetworks represents an opportunity to have access to the two types of resources, and to control the flow of them from one side to the other of the structural hole.

In real-life contexts, completely isolated subnetworks are fairly uncommon. However, real-life networks do have clusters relatively well defined (Watts, 1999; Jackson and Rogers, 2005) and certain individuals are more prominent than others bridging those clusters (Burt, 2005; Stovel and Shaw, 2012). 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 interaction– in the network as a whole. Individuals with higher betweenness centrality are expected to be more likely to put in touch two random individuals.

The interest for structural holes in economics has been fairly low. However, an extensive literature in other social sciences offers evidence on the advantages of being a broker. On the one hand, sociologists have found in several organizational environments that brokers are promoted more quickly, earn higher salaries, and have better evaluations from their superiors (Burt, 2004; Aral and Van Alstyne, 2011; Burt et al., 2013)[11]. On the other hand, in political contexts, authors like Padgett and Ansell (1993); Goddard (2009, 2012) show that brokers are more effective reaching agreements and controlling power.

Despite the lack of a formal theory of how brokerage operates, the above mentioned literature has identified two concrete mechanisms through which a broker profits from her position (see Quintane and Carnabuci, 2016). First, there is the *tertius gaudens* (i.e. rejoicing third) idea, which suggests that brokers can intermediate the interaction between the brokered parties in a strategical way. For instance, they can restrict information from crossing the structural hole. This gives them the advantage of having more information than the brokered parties. Second, there is the *tertius iungens* (i.e. third who joins) idea, which proposes that brokers can enable a direct exchange between the brokered parties. For instance, brokers can connect two individuals with complementary skills from opposite sides of the structural hole, whom would be disconnected otherwise. The broker could benefit from this by appropriating a fraction of the surplus resulted from the new interaction.

4 Empirical Strategy

4.1 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 "the big 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. In 1905 about 14% of the Colombian population lived in this region. The

[11] McGuire and Granovetter (2003); Burt (2008) has found similar qualitative results at macro level. Industries that bridge structural holes perform better.

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.

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 worth-mentioning features: it was a local-driven process made by a small and isolated group (i.e. the elite) and it took place in an environment dominated by market failures and a weak state capacity.

First, Antioquian industry emerged as the result of local efforts. Table 1 shows that the role of immigrants and foreign firms was quite small. 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[12]. This fact offers me the confidence that by analyzing the Antioquian case study I am capturing an "endogenous" process, which is not the result of external forces. Moreover, the elite that formed the industrial sector was quite small and isolated, which makes it ideal for the empirical endeavor of reconstructing a complete network (more on this in Section 4.2.1). This elite had no experience in manufacturing. This makes particularly simple to identify entrepreneurs. Any member of the elite who decided to create an industrial/manufacturing business was involving in a new risky productive activity, that is, she was an entrepreneur.

[Table 1 here]

Second, late 19th century Antioquia was a society in which markets and institutions worked poorly, making it a similar context to current developing regions (see Deaton, 2013; Banerjee and Duflo, 2011). In the first place, there were several types of inflexible labor institutions. This lead to the fact that only a small fraction of labor was effectively assigned through markets [13]. In the second place, access to land was quite restricted and faced enormous problems of property rights enforcement[14]. In the third place, banking and insurance markets

[12] This is a well-known fact in the business history of the region. Romagnoli (2000); Cerutti (1996); Birchal (1999) explore this extensively for Argentina, Mexico, and Brazil respectively

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

[14] 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 powerful entrepreneurial elite, leading to serious juridical, political and social conflicts (see LeGrand,

were quite restricted[15]. In the forth place, higher education was limited to one institution located in Medellin, which offered only medicine and law degrees[16]. Finally, all this was framed in a context of significant political turmoil that implied widespread uncertainty[17].

Unsurprisingly, this circumstances coexisted with fairly low living conditions. First, average households lived barely above the subsistence level [18]. Second, by the last decade of 19th century, fertility rate was around 7.4, and child mortality above 200‰(Flórez and Romero, 2010). Based on 1912 census, the adult literacy rate was 47%, and the gross primary school attendance was 36% [19]. In that sense, we are considering a fairly poor and rural society[20], in which entrepreneurship in the most advanced technology available emerged, even though there was no previous experience on the field[21].

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.

[15]Banks did not exist up until the 1870s. After their creation, they composed a fairly weak banking system concentrated in Medellin with severe loan constraints. In 1903 a financial crisis took out of business all the banks created during the 19th century that remained open at that time (Mejía, 2012). The elite from Bogota created in the 1870s the first insurance company of Colombia. This company monopolized the insurance market for several decades. It supplied exclusively protection against transport losses. By 1880s the company had an office in Medellin.

[16]In the late 1880s a mining school was created. It worked intermittently until the 1905, when it became a department at the local university. Mayor (1984) describes extensively the relation of this school with posterior industrial entrepreneurship.

[17]Despite the interest of the local politicians to offer a stable scenario for business, in which private property must 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, probably as common as in other regions of the country (see Botero, 2003).

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

[19]Literacy rate calculated based on population over 18 years old, and school attendance with population between 1 and 12 years old.

[20]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, Medellin, had 54,916 individuals and was the only municipality with a population larger than 30,000 (Carreño, 1912). Even Medellin was a quite rural town; 48% of the population lived outside the urban area (DANE, 1976).

[21]For centuries, the dominance of mining in Antioquia left little resources available for any sort of craft production. Almost every manufactured good consumed in the region was imported. In 1881 the US Consul in Medellin wrote that "everything is imported from the outside: the expensive dress for the elegant women, and the burden cotton cloth for the farmer" (Brew, 1977). Therefore, until the second half of the 19th century, there was essentially no industrial activity in the region.

4.2 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, historic and biographical data. From this collection resulted two completely new datasets. The first dataset contains information of members of the Antioqueña elite during the 19th and 20th century–relational data and individual attributes. The second dataset includes the information of industrial firms founded between 1850 and 1930–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.

4.2.1 Relational data and individual attributes

The first part of the dataset presents information of 1876 people belonging to the Antioqueña 19th- and 20th-century elite. 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 develop 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 of observations 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 certain bias concerns. I deal with those in Section 6.3.

The starting point of my snowball–i.e. the seeds–were the four largest shareholders of the banking system by 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[22]. 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[23]. 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 is a sample of 953 people, for whom we have a biographical profile and the 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 marginal role in the public life during the period of analysis. Their participation in business, political and intellectual projects was quite small. However, women were fairly 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, that cannot be expelled because it would break the network configuration.

Therefore, this second component pretends to minimize those biases by expanding the sample through a broader strategy that does not relate to the starting point of the snowball. The strategy consists in inspecting projects considered representative of the elite's spheres of interaction–e.g. social clubs, intellectual associations. The members of those projects are included 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

[22]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 (2012).

[23]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.

of society.[24] 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. The largest part of the individuals were in their productive lives in the last two decades of the 19th century and the first three of the 20th century (see Figure 2).

[Figure 2 here]

The sample seems to be a good representation of the local elite of the period. Section 11.2.3 gives details on this. For giving a sense of the type of population the elite was, consider the composition of the activities of the sample presented in Table 2. They coincide with the qualitative evidence described by authors like Brew (1977), Poveda (1981), and Davila (2012), who suggest how generalized were commercial and banking activities among the elite. The minor participation, but not infrequent, in other activities is also identified by those authors as a common pattern of this population. The fact that 116 people were founders of industrial projects, 9% of the sample, is reasonable for an agrarian society, in which industry was just emerging.

Also consistent with the historiographical evidence, the spatial distribution of the sample– considering their place of death as a proxy of the place where they lived during their adulthood and developed their activities–is largely concentrated in Medellín, which was the epicenter of the Antioqueña elite, followed by intermediate cities like Rionegro and Manizales (see Table 2).

[Table 2 here]

4.2.2 Firms' attributes

The second part of the dataset contains information about the ownership and productive structure 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 number of workers, the founding and closing dates, and the identity of the founders. Despite the absence of frequent sectoral

[24] Despite the ambiguity of this idea, it is easy to see that is closely related to the classical definition of elite as a small group of people who control a disproportionate fraction of a particular social sphere (Bottomore, 1993).

censuses, the quality of business history studies on the region offers confidence that the data collected include almost all the relevant entrepreneurial projects founded until 1930.

The amount of information available varies considerably among firms. I found 287 firms involved in industrial activity, for which I know their constitution dates and their activity at a very granular level. For 125 of them I have records of their shareholders identity and their capital structure. They had in average 5.4 shareholders. 96 of those firms had shareholders identified in my network dataset. Additional information about the performance of these firms is available for a subset of them (see Table 3).

[Table 3 here]

Based on the information available one can notice that the firm data is consistent with the most salient narratives of the region's industrial history. Firstly, the timing of industrial expansion described by authors such as (Botero, 1985; Davila, 2012; Brew, 1977) follows the pattern of my data: a slowly increase in the creation of firms in the second half of 19th century, with a small boom during the early 1900s, which was followed by the massive expansion of 1920s and and the relative decay after the Great Depression (see Figure 1). Secondly, my data describes an industrial sector almost completely dominated by manufacturing activities, something that (Echavarría, 1999; Montenegro, 2002) have extensively shown(see Table 4). Finally, as it is also widely accepted by all the authors previously cited, the industrial activity located mostly in Medellin 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).

[Table 4 here]

This dataset will offer information about the entrepreneurial behavior individuals in industry.

4.3 Networks

Based on the relational data I reconstruct the social networks and calculate the connectivity of individuals. Initially, I describe the networks as static objects, which is the most common approach in the literature. Then, I describe their temporal dimension.

4.3.1 Statics

Table 5 summarizes the criteria used in the construction of the networks. These criteria attempt to maximize the accuracy of the information collected. For that reason, they avoid what might be considered weak ties, which are unlikely to be well-identified in the historical records[25] [26].

The strictness in the inclusion rules of ties brings some costs. Primarely, one might miss a set of ties that played an important role connecting the network. This might increase the concerns 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 the 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* [27], which both gathers the different dimensions of interactions and draws them from several different sources.

[Table 5 here]

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 6 presents the aggregate metrics for each network. In the first place, the table shows the number of non-isolated nodes, which counts how many individuals have ties in that particular network. Based on this, we can see that the networks are quite heterogeneous; while the banking network has about 650 nodes, the mule-driving network has 15. Table 6 presents the number of edges, which captures a different idea of the size of the networks. In this dimension

[25] For instance, for constructing the political network, instead of selecting my 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.

[26] This argument does not ignore the strength of weak ties argument (see Granovetter, 1973). As I discuss in Section 7, most of the mechanisms that drive my results points out the importance of weak ties. The prioritization of relatively stronger ties is simply a empirical decision that seeks to capture the most accurate network possible.

[27] The complete network includes all social relations besides banking. The reason for excluding banking is that it was 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 exceptionally high average degree of the banking network; 325.

there is also a significant heterogeneity between the networks: the banking network has more than 100,000 edges, while the mule-driving network has about 120. Both of these facts are consistent with the historiographical evidence. Banking firms were the first corporations in the local economy, while mule-driving was a traditional business in which ancestral association practices, based on a small number of partners, were dominant until the 20th century.

[Table 6 here]

Another aspect in which these networks considerably differ is in their density. By comparing networks with similar sizes, it is possible to see that there are some fairly dense, like civic networks, and others much less dense, like friendship networks. Similarly, while banking is a highly dense network, the political network is much less dense, despite being smaller. This is also intuitive, while modern and large businesses require increasing efforts in multilateral cooperation and supportive ties, politics has more stable relational interactions, in which bilateralism dominates.

4.3.2 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 7 describes the evolution of the network over time. Consistently with the sampling process, the network grows since the late 18th century, having a maximum size by 1890s, after what it starts its decay. Nevertheless, for *the core period* (1850-1930)–when we have industrial entrepreneurship information–the network seems to have a stable pattern, with an average degree close to 6 and an average path length of four steps for the giant component.

[Table 7 here]

On the other hand, Figure 3 describes the variation in the connections' duration across networks. While there are types of connections that have a long duration, such as family, friendship, and intellectual ties; there are some others that have a shorter duration, 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. Hence, I will use edge duration data in Section 7 for interpreting the mechanisms through which social interactions affected entrepreneurial behavior.

[Figure 3 here]

4.4 Descriptive Statistics

Getting into the details of the variables used for the estimation, Table 8 presents their descriptive statistics. On the one hand, the number of industrial firms founded will be the dependent variable. In average, every individual in the sample founded 0.15 industrial firms with a standard deviation around five times that value. The large size of the standard deviation compared with the mean suggests that we are facing overdisperse data. This will have certain implications for the inference process, which Section 4.5 discusses.

On the other hand, ego-density and betweenness centrality are the independent variables of interest. The first captures the closure/trust idea of social capital, while the latter captures the structural-holes/preferential-access idea. In theory, these two measures are negatively correlated. Individuals whose alters are highly connected to each other are not supposed to be particularly important bridges in the global network, because their alters have similar a location 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. While ego-density gives information about the local-level structure of the individual's network, betweenness centrality captures the position of the individual in the global network structure.

[Table 8 here]

In addition, as controls, I use gender, partisan affiliation, wealth of family in 1850, and place of birth, marriage, and death plus their correspondent years. Finally, at certain stages of the estimation I consider several confounding variables–based on what the literature suggests as relevant explanations for industrial entrepreneurship: such as being a banker, miner, immigrant, politician, merchant, and engineer–and additional features that might played a role as mechanisms: be part of a migrant family, having higher education or having studied abroad.

4.5 Model

In order to evaluate the existence of a relation between industrial entrepreneurship and social networks, I propose to observe the number of industrial firms founded by each individual. A larger number of firms founded represents a deeper involvement in industry. Hence, I am capturing industrial involvement through a counting variable.

The usual way of modeling count data is through a Poisson regression. However, as the descriptive statistics suggested, we are facing overdisperse data[28]. Therefore, I use a negative binomial regression model[29]. In any case, the results are robust to a standard Poisson specification (see Appendix 11.2.1).

Negative binomial regression assumes that the response variable has a negative binomial distribution, and that the logarithm of its expected value can be modeled by a linear combination of unknown parameters. Formally,

$$log\left(E\left(Y_i|\mathbf{X_i},\mathbf{Z_i}\right)\right) = \beta + \mathbf{X_i}\alpha + \mathbf{Z_i}\gamma + \varepsilon_i \tag{1}$$

Where Y_i are the number of industries of which the individual i was one of the founders. $\mathbf{X_i}$ is the vector that characterizes the network position of individual i. This is the independent variables of interest. $\mathbf{Z_i}$ represents relevant controls and ε_i the error term.

There are literally dozens of different network metrics that could be included in the regression. However, as most of these measures are highly correlated, a horse race approach does not seem appropriate. Instead, this paper stands on a well-defined theoretical base (i.e. the closure/brokerage discussion), which offers some logical structure of what measures should be included as regressors. In particular, $\mathbf{X_i}$ includes ego-density as a way of capturing how cohesive i's network is and betweenness centrality, for capturing how important as a broker the i is. From Section 6.1 onwards, a broader set of network measures will be included. In that case, those measures will be included as controls and their election will be supported on theoretical reasons as well.

In addition to Equation 1, I will estimate a longitudinal model. Concretely, for individual i at time t, I estimate the following specification:

$$log\left(E\left(Y_{it}|\mathbf{X_{it}},\theta_\mathbf{i},\tau_\mathbf{t}\right)\right) = \beta + \mathbf{X_{it}}\alpha + \theta_\mathbf{i} + \varepsilon_{it} \tag{2}$$

Where θ_i are individual fixed effects, which avoid confounding effects of non-observable

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

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

traits–one of the most common concerns in non-experimental network studies. In order to address some concerns about the performance of negative binomial regression with fixed effects (see Hilbe, 2011; Cameron and Trivedi, 2013), I also consider Poisson regression and OSL estimates. The latter will allow me to include time fixed effects, which are intended to capture any temporal impact of aggregate conditions specific to certain periods.

Notice that these specifications capture social interaction through aggregate network measures. In particular, 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; Moffitt et al., 2001; Bramoullé et al., 2009). More broadly speaking it requires a weaker set of identification assumptions than standard approaches on social interaction in economics (Blume et al., 2015). However, it is particularly susceptible to non-classical measurement error (Chandrasekhar and Lewis, 2011). Concern that I consider in Section 6.

5 Main Results

5.1 Statics

There are two main results (see Table 9). First, there is a positive correlation between betweenness centrality and industrial involvement. This correlation remains significant even after including every confounder. Thus, 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 16.6% more industrial firms than the average of identical individuals in observables. An complementary way of looking at the effect of brokerage in industrial activity is through the extensive margin (see A1). Individuals with one standard deviation higher betweenness centrality were 0.7% more likely to be industrial entrepreneurs.

The second result is a negative relationship between ego-density and industrial involvement in basic correlations. This means that individuals with a denser immediate network founded fewer industries. However, this result disappears after the inclusion of any confounder. Thus, once one considers occupational decisions, identical individuals in observables with networks of different densities did not differ in terms of the number of industrial firms they founded. Clearly, this reflects that network density was highly correlated with occupational decisions and that network density does not have an additional explanatory capacity once those are considered. The results for the extensive margin are identical.

Notice that these two results are robust to a whole set of different specifications and estimation approaches (see Appendix 11.2.1).

[Table 9 here]

Finally, there is an additional set of relevant results related to individual attributes. In simple correlations almost every suspected attribute related to industrial entrepreneurship shows a significant coefficient. However, just a couple of them–being a miner or a merchant–maintain significance with the introduction of controls. As I will discuss in Section 7, these results might shed light on the mechanisms behind the interaction of networks and industrial entrepreneurship.

5.2 Dynamics

I focus on *the core period* (1850-1930). Before this period there was no industrial activity and I do not record industrial data for the posterior decades. Results go in the same direction than the static ones (see Table 10)[30]. Betweenness centrality is positive and significantly correlated with industrial involvement. In particular, an increase in one standard deviation in betweenness centrality is associated with a 35.7% higher probability of being an industrialist, and a 30.3% additional industrial firms founded.

[Table 10 here]

In this specification, ego-density becomes significant. Section 6.1 shows that after controlling for the basic network measures this result dissipates.

6 Identification Concerns

6.1 Omitted Variables: Broader Effects of Network Position

Since the pioneer work of Knight (1921); Schumpeter (1934), studies on entrepreneurship have identified that entrepreneurial involvement and innovation are related to personality traits.

[30]Nonlinear fixed effects models have several shortcomings. Most of those come from the *incidental parameter problem* (see Arellano et al., 2007; Arellano and Hahn, 2016; 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. However, to be consistent with the cross-section analysis–and considering that a Poisson specification offers identical qualitative results–I will continue interpreting the negative binomial regression as the main specification. In addition, I present OLS estimates in the appendix, which are qualitative equivalent as well (see Table A5)

Some of those traits are hard to measure, for instance, preferences over risk or communication skills (see Carland et al., 2002; Åstebro et al., 2014; Kerr et al., 2015). At the same time, the literature in sociology has shown that personality traits determine a large amount of social interaction patterns, in particular, network location (see Burt et al., 1998; Burt, 2012). Therefore, a valid concern about the cross-sectional results from Table 9 is the existence of unobservable attributes that determine both the position of individuals in the network and their involvement in industrial activity. This concern is mitigated by longitudinal results that include individual fixed effects, which capture unobservable attributes like personality traits. Results from Table 10 are qualitative equivalent to those of the cross section analysis.

Nevertheless, a more complex problem of omitted variables remains. Other features of the network position correlated with betweenness centrality and ego-density might be confounding the effects of these metrics. As network measures change over time, individual fixed effects are not capturing them. For dealing with this, let me consider the three basic measures of centrality: degree, closeness centrality, and eigenvector centrality[31]. Table 11 shows that betweenness centrality and ego-density are highly correlated with degree and eigenvector centrality, implying that omitting these variables might be a relevant concern.

[Table 11 here]

Table 12 shows how the inclusion of degree and eigenvector centrality affects the results from Table 10. Despite the decay in the magnitude of the betweenness centrality coefficient–it passes from 30.3% to 10,4% in the negative binomial regression, and from 35.7% to 21% in the logit one–it remains positive and highly significant. Meanwhile, ego-density significance completely disappears. Therefore, the omission of these metrics does not drive the results from tables 9 and 10.

[Table 12 here]

In Section 7 I discuss the meaning of the significant coefficients of degree and eigenvector centrality.

[31] Degree counts the number of immediate contacts of a node (i.e. how many people an individual knows). Closeness centrality is the inverse of the average length of the shortest paths between a node and all other nodes (i.e. how close are the rest of the people from an individual). Eigenvector centrality is a more complex measure of the influence of a node in a network, which considers the connections of the connections of a node. Concretely, eigenvector centrality corresponds to the values of the first eigenvector of the graph adjacency matrix.

6.2 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[32]. Hence, the results from Tables 9 and 10 might be the effect of industrial entrepreneurship over social networks and not the other way around. For tackling 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 assure to break the reverse causality issue because current entrepreneurship cannot explain past social interaction.

Table 13 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 have a reverse causality bias. It might also be a regular reduction of the effect of networks because of the pass of time. In any case, this exercise shows that the results from tables 9 and 10 are not completely driven by a reverse causality issue.

[Table 13 here]

Table 13 offers additional insights on the persistence of the correlation of network position and entrepreneurship. In particular, it shows that the very antique–more than two decades–positions in the network do not significantly correlate with entrepreneurship or it does but it follows the opposite direction than the contemporary correlations. This suggests that the data underneaths an active network formation. Even though a better understanding of the network formation process in the long-run is a fundamental step in the agenda that the paper opens, it escapes the scope of the paper itself.

6.3 Measurement Error: Sample Construction Bias

There is extensive literature on the potential inference bias over sampled networks (Smith et al., 2017; Wagner et al., 2017; Smith and Moody, 2013; Wang et al., 2012; Chandrasekhar and Lewis, 2011; 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 population network–because it ignores a set

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

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 *ascending* and *descending sampling methods*. 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 4.2.1). This strategy does not solve completely the conflict between representativeness of nodes and edges. However, I show in Section 11.2.3 that it alleviates every concern of sampling-error biases that could be driven my main results.

7 Mechanisms

By combining the results from my estimations and a collection of narratives from the economic history of the region, it is possible to shed light on the mechanisms behind the relations between industrial entrepreneurship and social networks.

7.1 Social Networks Substituting Markets

Industrial production is a highly complex activity. Development theorists have thought of it as a late stage of capitalism, which needs the preexistence of other well-developed sectors such as agriculture and banking (Rostow, 1960; Hirschman, 1958; Galor, 2011). 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 emerge–e.g. the formation of wage labor, the accumulation of capital, etc.. At an entrepreneurial level, this implies that creating an industrial firm 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.. These ingredients are expected to be provided by complete and well-functioning markets. For instance, the large amounts of capital that industrial firms need would be covered by a well-functioning capital market–i.e. without major frictions.

However, in the late 19th-century Antioquia that was not the case. Markets were far from being well-functioning. Continuing with the capital market example, banks did not exist up until the 1870s. After their creation, they composed a fairly weak banking system concentrated in Medellin with severe loan constraints (Botero, 1984). The following sections show that market failures did not limit to the capital market.

Under those circumstances, entrepreneurs could not support their activity on market resources, what left them with social connections as their only way for reaching the required ingredients for creating industrial firms. As these ingredients were distributed sparsely in the society, those individuals who bridged the network were more likely to gather them, and therefore, to become industrial entrepreneurs. In that sense, my main results are capturing that: individuals more important as bridges in the global network (i.e. individuals with higher betweenness centrality) were more deeply involved in industry, because they had access to a more diverse set of resources, which give them a competitive advantage for creating industrial firms in a context of poorly functioning markets.

If this interpretation of the main results is correct, betweenness centrality should have been more important for entrepreneurs in communities with lower market development. As described in Section 4.1, Antioquia was a fairly large region with a dispersed settlement pattern. This provides spatial variation in the development of markets to test the above mentioned interpretation. Table 14 shows the result of such test.

[Table 14 here]

Table 14 presents a set of similar specifications to the ones of Table 9, including as independent variables market development and an interaction of betweenness centrality and market development[33]. 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 above mentioned interpretation of the main results of the paper.

The following sections go into the details of how social networks helped to surpass the limitations of market underdevelopment.

[33] I measure market development as the ratio of the number of employees over the number of *jornaleros* for municipalities in 1912 Census. Employees 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 the traditional labor figure in Colombia, closely tied to ancestral serfdom institutions. They 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 proxy of the relative importance of markets in the economy.

7.1.1 Market Size

There were severe constraints on market access. Part of it was related to geographical conditions. For instance, 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). Hence, reaching the size of the market that made the production efficient enough was a complete challenge. Moreover, the distribution system was already dominated by a well-established group of competitors–i.e. the merchant elite. For this reason, authors like Botero (1985) describe the importance of being connected to the merchant elite in order to sell industrial products at local level[34].

In that way, several industrial companies emerged partly as spin-offs of *commercial houses*–e.g. *Fabricato*, *Coltejer*. These houses were the dominant associative figure for doing business during the period. Typically, they were founded by two partners, one of which contributed the capital, while the other contributed her labor, having each one an equal part of the property of the firm. These societies were frequently backed by family or marriage relations. Commercial houses that associated people with no family ties were quite infrequent. In that sense, entrepreneurs had to be well-connected at business level, but they also had to be embedded in a broader social sphere. Thus, as I present in Section 7.2 what seems to matter is to be central at the aggregate networks. Centrality in local networks does not seem to be enough.

7.1.2 Substituting Incumbent Production

Entrepreneurs had to generate taste for new products and compete in a quite rigid market. Manufacturing consumers were used to imports or to traditional-style products. Brew (1977) presents several cases of industrial failure before the 20th century in which the main problem was their incapacity to substitute incumbents production. Among those cases Brew mentions the experience of local cigarettes against the incumbent Cuban cigarettes, and local beer against the overwhelming preferred *aguardiente*. Henceforth, being able to influence local opinion and consumers' preferences was important. This was usually made through the Church and the media–newspapers, mostly.

Another mechanism for competing with incumbents was to look for political protection. Table 15 summarizes some of the public interventions on industrial activity in the region during

[34]Botero (1985) illustrates this point in the following terms: "stores and shops remained as key activities, because it was in those places were foreign merchandise was sell. In addition, they sold their on clothes... This was the perfect integration: traditional importers of clothes had a secured customer base and well-located stores where they distributed the clothes they now produced".

the period. The largest part of those policies consisted in protecting new industries from competition. Authors like Ospina (1955); Uribe and Alvarez (1988); Mejía (2015b) show that these protective measures were associated with ties between politicians and entrepreneurs[35].

[Table 15 here]

7.1.3 Financial Constraints

Industrial entrepreneurs faced several financial constraints. On the one hand, the initial size of industrial firms was fairly large. As I mentioned previously, only 0.047% of the population had private fortunes large enough for being an average industrial entrepreneur. On the other hand, besides the initial capital requirements, firms of this size needed a trust-worthy flow of liquidity that was clearly absent in Antioquia during the period. For instance, Brew (1977) describes that, after some monetary reforms in 1888, several banks canceled loans already assigned to industrial firms, putting more pressure over equity and shareholders connections as funding resources.

Henceforth, authors like Safford (1967); López Toro (1970) emphasize the role of mining profits and the configuration of familiar and commercial links, in accessing the capital that became the base for the first industrial projects. Arango (1977); Bejarano (1980) emphasize the profits of the coffee business. In general, the rational of both arguments is the same, entrepreneurs strategically connected to productive sectors that enjoyed export booms could invest in industry, thanks to the capital offered by the surpluses of those activities.

7.1.4 Technology

Local entrepreneurs lacked technological knowledge for offering high-quality products. An illustrative example were the first pottery projects at industrial level. For several decades, local pottery firms were not able to produce ceramics or glass products because of their misconception of the geological composition of their mines. Hardware companies faced similar problems. For instance, *La Ferrería de Amaga* used a certain type of wood that had insufficient heating power for iron production. This made them unable to compete with imported iron for several decades.

Given the absence of a human capital market, this lack of technical knowledge could only be solved by entrepreneurs connected with individuals who had that knowledge, and could provide it to the organization. The foundation of *La Locería de Caldas* (the most successful

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

ceramics firm) exemplifies this. It was founded by a small group of partners that included two migrant technicians, one of which became the manager. He traveled to Europe to bring the machinery, and two technicians to work in the factory.

A large number of studies (e.g. Mayor, 1984; Mejía, 2015b; Brew, 1977) describe that certain elite families use marriages and other kinds of interactions to incorporate European migrants to their social circles[36]. Those migrants came, in the first place, as engineers for the gold mines. They ended up being a reliable channel for knowledge diffusion among local entrepreneurs.

Another mechanism through which migrants transmitted technological knowledge to local entrepreneurs was by contacting them with universities abroad. A whole generation of some elite families was educated in technical areas in Europe and the US, thanks to the contacts of migrants. Upon their return, this group of newly trained families brought the knowledge that fed the *Escuela de Minas*–the first Engineer School of Colombia–and some of the first industrial projects. The families that were closer to the immigrant community, as the Vásquez, the Restrepo, and the Ospinas, were the ones who made the transition from traditional elites, to industrial elites. Once again, in that case it was not closure, but brokerage–between traditional elite networks and immigrant networks–which originated the productive advantage.

7.1.5 Machinery Import

Technological knowledge leads us to the fifth challenge faced by entrepreneurs; machinery import. First, all the machinery had to be purchased in foreign markets, implying a quite complex process of acquiring the information about the machines and stabilizing the connections with the foreign companies for making a successful purchase. Moreover, 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–e.g. Buenos Aires or Sao Paulo, where the internal transport of the machinery, once arrived to the national port, did not imply much more than a calm couple of hours/days trip, whereas in Antioquia this process usually took months in quite harsh circumstances. First, it took a 70 days trip by boat from the port in the coast (Barranquilla) to the port in the closest river (Puerto Berrio) (Poveda, 1998). Then, reaching Medellin implied to cover over 250 kilometers by mule in the difficult mountain conditions described above, which took several weeks[37]. This process

[36]Notice that the size of the immigration in Antioquia was quite small in comparative terms, both with Latin-American and Colombian standards.

[37]A railroad from Puerto Berrio to Medellin was approved in the mid 1870s. It was not finished until the early 1920s, but sections of the railroad were available progressively before. By 1905 only 66 kilometers were available. For the other industrial capitals of the region 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, 2015)

brought a whole set of technical challenges and risks. For instance, in the case of the textile firm *Compania Antioquena de Tejidos*, the machinery arrived completely broken after the trip from England, so that it needed to be repaired by locals at a high cost.

Entrepreneurs could not face this sort of risks with market or state-driven solutions, because there were no insurance markets or reparation policy from the State. Thus, entrepreneurs used their personal ties to mitigate those risks. For example, Safford (2010) describes that local entrepreneurs had to emphasize to the sellers in Europe to give additional protection to the cargo, so it could survive the trip. Once again, the effectiveness of this implied the strength of the interaction with the European seller.

These challenges were related mostly to the geographical isolation of the region. Even though they were highly problematic for machinery imports because of their dimensions and conditions, to some extent they were also experienced in every import/export activity[38]. Merchants had dealt with them for decades and were embedded in international-trade networks that offered fairly efficient solutions to them. In that sense, being in touch with merchants was essential for any industrial entrepreneurship.

7.1.6 Political Turmoil

The political convulsion made all the previous challenges bigger. For instance, civil wars hindered even more machinery imports. In civil wars the ships used for transporting imports to Antioquia from Barranquilla were frequently sunk or captured by the armies (Poveda, 1998). This increased transport costs significantly during those periods and made it essential to have connections with politicians and the military in order to procure the recovery of the cargo.

Following this idea authors like Uribe and Alvarez (1988) and Mejía (2015b) argue that successful entrepreneurs had frequently personal relations with political actors, and, usually, they were politicians themselves. Biographical studies from local entrepreneurs such as Pepe Sierra, Coroliano Amador, Eduardo Vásquez, and Pedro Nel Ospina showed that their privileged position between entrepreneurial and political spheres was key to their entrepreneurial success. For instance, Pedro Nel Ospina and Eduardo Vásquez, were involved in the foundation of the first electric company of Colombia, in which the government of Medellín was also a partner. In that case, it was not the cohesion of their network what drove them to the industrial activity, but their brokerage was the relational source of profitable advantages.

Nevertheless, political connections were not enough to overcome the costs of political

[38] Actually, similar kind of difficulties existed for local inputs.

turmoil, because it also set general macroeconomic uncertainty. Consider The Thousand Days Civil War (1899-1902). This war generated a huge currency risk. In Medellin's market, one British pound was exchanged for 3,35 Colombian pesos in January of 1899. In September of 1902, people needed 110 Colombian pesos for buying one British pound Meisel (1994). With this type of uncertainty entrepreneurs had to adopt different mediums of exchange and store of value, gold was the common choice in the region. This implied advantages to those connected with miners. This relation of mining and industry is explored extensively by Safford (1967); López Toro (1970).

7.2 Social Networks as Collectors of Decentralized and Complementary Resources

Notice two things from the previous section. First, most industrial activities required the solution of all those six challenges. For instance, having the capital, but lacking the skills to import the machinery was not enough for creating a firm that intended to use a capital intensive technology. In that sense, becoming an industrial entrepreneur was not an issue of having the appropriate "ingredient" (i.e. a skill or resource), but about 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. For instance, miners 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 combined implied that in order to get involved in industrial activity, an individual needed several types of simultaneous connections (i.e. connections with politicians, merchants, miners, etc.). In that sense, the essential network feature that offered an advantage for industrial entrepreneurship was a position with a low cost of accessing a wide variety of nodes' types.

Two pieces of evidence support this claim.

The first piece of evidence comes from Figure 4. It shows that being a more important broker (i.e. to have a higher betweenness centrality) is positively correlated with industrial involvement only in the aggregate-networks (i.e. complete, traditional, and modern networks). When considering single-networks, being a more important broker was not related to industrial entrepreneurship (see Figure 4, Panel A). In contrast, high ego-density in "critical" single-networks–i.e. transport, mining, and friendship–was positively correlated with industrial involvement, but this correlation becomes non-significant at the aggregate-networks level (see Panel B).

[Figure 4 here]

One possible way of interpreting the conjunction of these two results is the following. On the one hand, resources required for industrial entrepreneurship could be more efficiently collected if individuals had a denser network in the particular spheres where these resources circulated (i.e. the "critical" single-networks). For instance, an individual in a denser transport network would be expected to have: a more accurate understanding of the operation of the firms in the sector; a goodwill within the group of agents involved in this activity; and a stronger position for asking them for help. In that sense, it is expected that such individual would be more likely to solve the distribution problems above mentioned than someone with a peripheral (or completely absent) position in that network. However, these mechanisms are not expected to operate once different types of ties are aggregated because the kind of resources and information that flows through each type of tie might be different. For example, business technicalities are not usually discussed within family, and personal matters are not frequent in discussions with business partners. Therefore, to have a network in which several alters interact among them, but some of them do it in the transport, the intellectual, and the family network do not seem to offer the clean flow of information that characterized the trust/closure argument (see Section 3). In other words, closure, as I measure it in the complete network, does not represent an advantage for collecting complementary and decentralized resources, as the ones you needed for creating an industry in 19th-century Antioquia.

On the other hand, brokerage was not relevant at the single-network level because these networks are expected to be composed by fairly homogeneous nodes. Thus, to be a bridge within people with similar resources and information did not represent an advantage for collecting the disperse industrial inputs. Nevertheless, brokerage was relevant at the aggregate-network level because, no matter the type, every tie represented a mechanism for reaching individuals' resources. For example, if an entrepreneur needed an engineer, and she was aware that a friend of hers knew one, she might have been able to contact the engineer through her friend, no matter if the tie between the engineer and the friend had a family, an intellectual or a business nature. In that sense, brokerage, as I measure it in the complete-network, represented a higher likelihood of collecting complementary and decentralized resources, as the ones you needed for creating an industry in 19th-century Antioquia.

The second piece of evidence supporting the claim that social networks worked as collectors of decentralized and complementary resources is the correlation of industrial involvement degree and eigenvector centrality (see Section 6.1). First, as shown in Table 12, the number of direct connections (i.e. degree), which is the most immediate network attribute of access to resources, is highly correlated with industrial involvement–one standard deviation increase in degree is related to a 56% increase in the number of industrial firms founded. Notice that this is the expected correlation in a context where industrial-activity inputs are decentralized and complementary. In such a context, a higher degree implies a larger probability of collecting the set of inputs required and, therefore, an advantage in industrial entrepreneurship. Somehow less intuitive is that after controlling for degree, eigenvector centrality is negatively correlated with industrial involvement. The reason is that eigenvector centrality has little to do with accessing resources. It is rather a measure of prestige and power in the global network, which implies comparative advantages in other activities like politics, for instance. In that sense, what Table 12 is rather a substitution effect, which captures the capacity of an individual to influence the rest of the network, and does not indicate her capacity to absorb resources from the network.

8 Concluding Remarks

In this paper I try to understand if the location of an individual in her social network relates to her decision to undertake entrepreneurial projects. In order to do this, I construct the social network of the elite of Antioquia (Colombia) in the late 19th and early 20th century. This was a society in transition to modernity, characterized by difficult geographical conditions, market failures, and weak state capacity, just as most current developing regions. The paper uses discrete choice models to estimate how the decision to found industrial firms was affected by the features of the individual's network. In particular, I focus on two network measures: betweenness centrality and ego-density. Betweenness centrality captures how important an individual is 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.

The paper has two main results. On the one hand, I find a positive relationship between industrial involvement and betweenness centrality. Concretely, an increase in one standard deviation in betweenness centrality was associated to 12.1% additional firms founded with regard to the mean. This is equivalent to an increase of 9.4% in the probability to become an industrial entrepreneur. This relation is robust to different types of estimation methods, to the inclusion of every reasonable control, and, in general, to every major endogeneity concern. On the other hand, I do not find a robust relationship between ego-density and industrial involvement.

These correlations must not be considered causal effects. However, based on narratives and additional historical data I argue that these results come from the role of social connections as supplements of 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. with higher betweenness centrality) had a comparative advantage in industrial entrepreneurship. Meanwhile, having a supportive social circle did not guarantee accessing all the required resources.

These results empirically support the importance of group diversity in individual performance and problem solving (Hong and Page, 2001, 2004; Lazer and Friedman, 2007; Page, 2008). Moreover, they increase the evidence on the correlation between social networks and productive activities in developing environments. Nevertheless, 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; Chandrasekhar et al., 2014; Breza et al., 2015) or that allow the diffusion of innovations (Conley and Udry, 2010; Banerjee et al., 2013; Miller and Mobarak, 2014; Cai et al., 2015), this paper highlights that social networks play a crucial role as a general method for collecting inputs for production.

In methodological terms, this paper is part of a growing literature that exploits historical data at individual level in order to answer development/policy related questions (Costa and Kahn, 2007; Abramitzky et al., 2012). However, in line with recent studies like Xu (2017); Squicciarini (2017); Clark and Cummins (2015) I contribute by going beyond official records, doing an extensive archival research. This type of archival research implies crossing a large number of sources from different origins, offering a richer content of information than traditional approaches, which limit themselves to administrative data.

Finally, this study has implicit policy suggestions. The constraints to entrepreneurship that individuals in Antioquia faced are fairly similar to the ones that people from developing regions face currently. Markets do not work properly, formal institutions are weak, and there are latent technologies that local entrepreneurs do not risk to embrace. In those contexts, solving a particular constraint is not enough. And as it is impossible to create a policy that solves all the constraints, the poor performance of entrepreneurial policies, in general, is not surprising (see Shane, 2009; Brown et al., 2017). In that sense, this paper highlights a potential mechanism for improving the entrepreneurial capacity of individuals in these regions in a fairly spontaneous way: to strengthen the connectivity in their social network. This result goes back to the literature on social capital in development (Putnam et al., 1994; Bowles and Gintis, 2002; Ahlerup et al., 2009; Munshi, 2014) and relates to recent works that consider social networks a supplement of weak markets and institutions (De Clercq et al., 2010; Danis et al., 2011; Lindner and Strulik, 2014). However, this paper reconsiders what type of interactions should be promoted. Instead of strengthening community or business interactions in a broad way, the implications of this paper are to make individuals connected to a more diverse group of alters through significant ties, enabling the conjunction of potential complementaries.

Obviously, there are threats to this recommendation related to general equilibrium effects and external validity. On the one hand, authors like Goyal and Vega-Redondo (2007); Kleinberg et al. (2008); Buskens and Van de Rijt (2008) show theoretically that the dynamics of network formation in contexts in which everyone tries to be a broker tend to dissipate the exceptional profits of those positions in the long-run. Thus, efforts to promote massively the connectivity of individuals might generate undesired effects. On the other hand, one might argue that the modern sector nowadays (i.e. high-tech), differs radically from industry and, therefore, any attempt to lead entrepreneurs to the frontier of productive technology will face different sorts of challenges that the Antioquia case does not capture. However, testing the validity of these concerns is beyond the scope of this paper.

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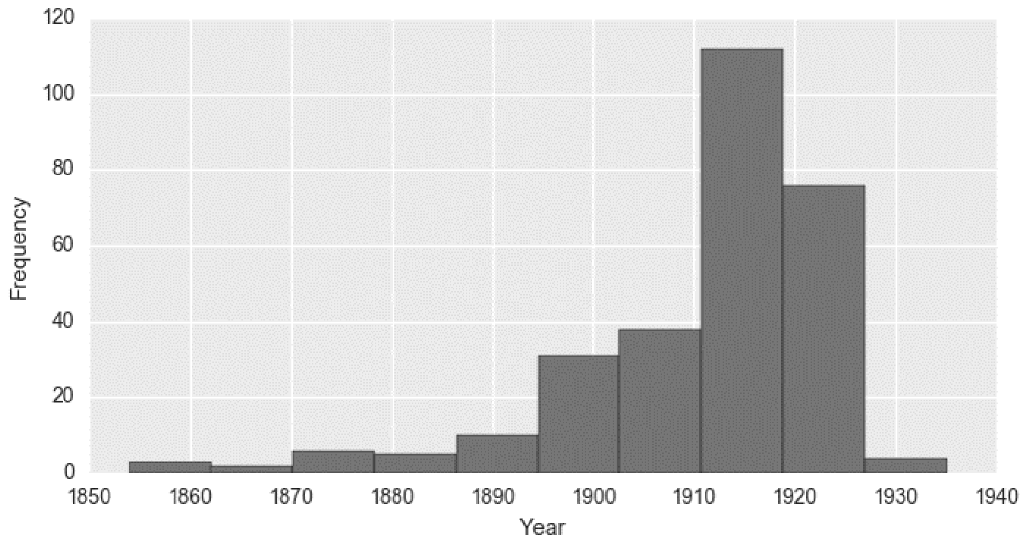
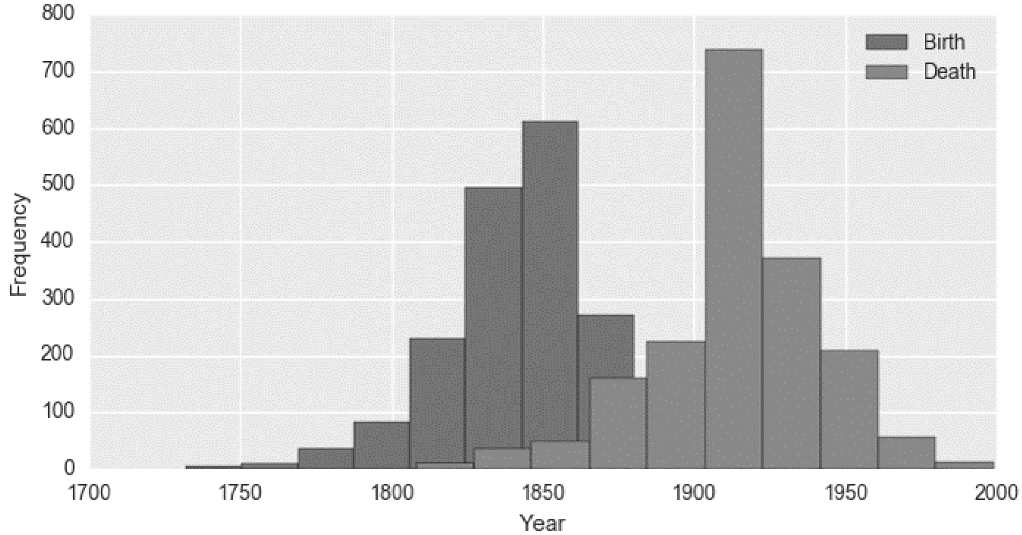
9 Figures

Figure 1: Firm size and year of foundation. Industrial firms in Antioquia. Histogram



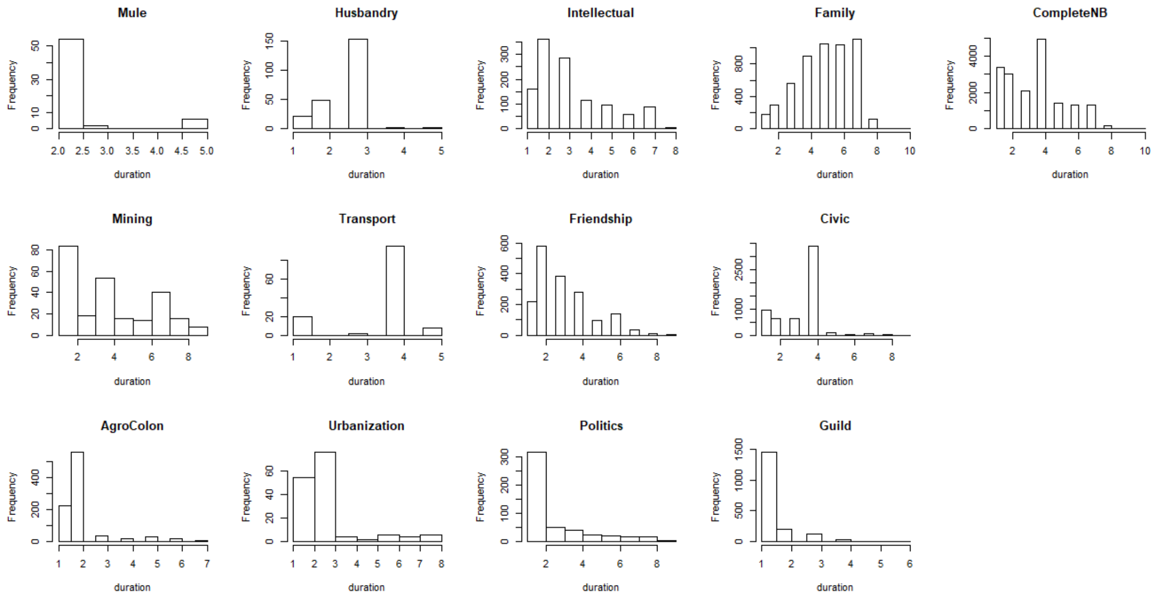
Note: This figure presents the number of industrial firms in my sample created by period of time.

Figure 2: Death and birth dates. Elite of Antioquia. Histogram



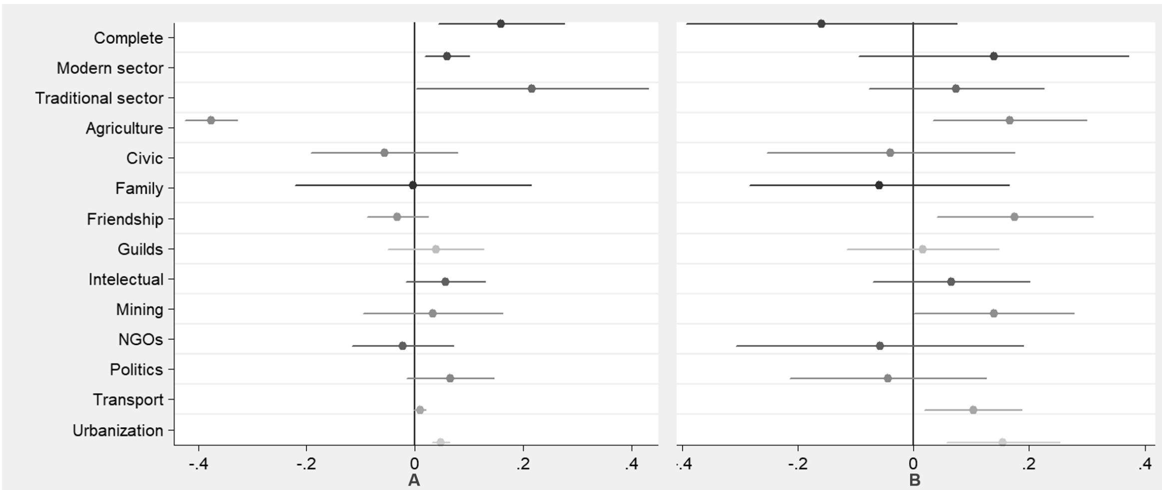
Note: This figure presents the number of individuals in my sample that were born and died by period of time.

Figure 3: 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 survives) for a particular type of interaction. An edge is born once an interaction between two nodes is identify. An edge disappears if there is information about the destruction of the interaction, o if one of the nodes that compose the interaction dies.

Figure 4: Cross section: Industrial Entrepreneurship and Social Networks by Type of Interaction. Coefficient Plot



Note: This figure presents the social network coefficients (i.e. point estimates and 95% confidence intervals) of 14 regressions that replicate the 9th specification of Table 9 (i.e. includes controls but not confounders). Thus, each regression considers one particular dimension of interaction (i.e. they include the betweenness centrality and ego-density measures for one of 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 has the betweenness centrality coefficients and Panel B the ego-density coefficients.

10 Tables

Table 1: Industrial entrepreneurship and migration. 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 America.
Source: (Maloney and Zambrano, 2017)

Table 2: Individuals' attributes. Elite of Antioquia

Occupation	Obs.	City of death	Obs.
Merchant	208	Medellín	597
Miner	78	Bogotá	55
Landowner	69	Rionegro	70
Politician	223	Manizales	40
Intellectual	129	Sonsón	22
Farmer	78	Abejorral	17
Industrial	116	Pereira	16
Banker	670	Santafe de Antioquia	13

Note: This table presents the number of individuals in my sample by occupation and place of origin. Occupations are not exclusive and are only available for the first component of my sample.

Table 3: Firms' attributes. Industrial firms in Antioquia

	Obs.	Mean	Std Dev.	Min.	Max.
Foundation date	287	1911	12.62	1854	1935
Closing date	33	1930	38.54	1876	2015
Initial capital	96	16902	83284.70	2	600000
Employees (1920)	70	88	106.57	2	550
Shares	53	1696	6940	4	50000
Share value	54	12.62	27.24	0	150

Note: This table presents descriptive statistics of the industrial firms in my sample.

Table 4: Firms by sector and location.
Industrial firms in Antioquia

Sector	Firms	Location	Firms
Manufacturing	277	Medellin	172
Other	4	Pereira	10
Construction	4	Caldas	6
Electricity	4	Envigado	5
Water supply	1	Manizales	4
Petroleum	1	Bello	3
Communication	1	Other	6

Note: This table presents the number of industrial firms in my sample by sector and location. For several firms there is no information about their location.

Table 5: 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
	Traditional Sector	**Urbanization**	Urbanization shareholders	Shareholders of the same company	Number of interactions	1880-1930
		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 does not mean that every individual in the sample is part of the specific single-network, but rather that any individual in the sample could be part of that single-network.

Table 6: Cross section: Main characteristics of the social networks

Network	Non-isolated Nodes	Edges	Average degree*	Diameter	Density*	Connected Components
Complete**	1,876	11,717	12.5	14	0.003	8
Family	903	4,781	5.1	18	0.001	23
Political	228	320	0.34	9	0.0009	14
Friendship	184	979	1.04	5	0.0003	23
Intellectual	153	723	0.77	9	0.0002	11
Traditional Sector**	162	738	0.79	9	0.0002	15
Agriculture	83	469	0.5	2	0.0001	15
Mining	57	125	0.13	5	0.0004	7
Animal Husbandry	26	113	0.12	1	0.0003	4
Mule Driving	15	37	0.04	1	0.0001	4
Modern Sector**	685	105,871	112.87	5	0.03	3
Banking	651	105,653	112.63	4	0.03	1
Urbanization	23	75	0.07	2	0.0002	3
Modern Transport	19	145	0.15	2	0.0004	3
NGOs[b]	282	4,111	4.38	7	0.01	4
Civic	193	2,957	3.15	7	0.0008	6
Guilds	101	1,159	1.24	4	0.0003	4

Note: This table presents descriptive statistics of the social networks in the static framework.
*Based on the total number of nodes.
**For agglomerated networks the set of nodes is the union of the set of nodes of the individual networks. The set of edges is the union of individual edges. Edges are weighted by number of repeated interactions.

Table 7: Panel: Main characteristics of the complete network

Decade	Non-isolated Nodes	Edges	Average Degree	Density	Diameter	Average Path Length
1770	28	34	2.4	0.090	2	1.1
1780	61	105	3.4	0.057	2	1.2
1790	93	140	3.0	0.033	6	2.2
1800	166	249	3.0	0.018	11	4.5
1810	288	396	2.8	0.010	13	5.0
1820	413	618	3.0	0.007	14	5.1
1830	516	950	3.7	0.007	10	4.8
1840	1,144	3,398	5.9	0.005	15	4.7
1850	1,334	3,671	5.5	0.004	16	5.0
1860	1,490	4,081	5.5	0.004	17	5.2
1870	1,566	4,681	6.0	0.004	16	5.2
1880	1,504	3,305	4.4	0.003	16	5.1
1890	1,744	3,447	4.0	0.002	14	4.7
1900	1,319	2,844	4.3	0.003	15	4.6
1910	706	3,024	8.6	0.012	12	4.3
1920	508	2,116	8.3	0.016	11	3.8
1930	315	938	6.0	0.019	14	4.3
1940	175	322	3.7	0.021	11	3.9
1950	81	58	1.4	0.018	4	1.6
1960	33	12	0.7	0.023	2	1.2

Note: This table presents descriptive statistics of the complete social network in the dynamic framework.

Table 8: Cross section: Descriptive statistics. Elite of Antioquia

Variable	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
Number of ind. firms founded	1876	0.15	0.61	0	8
Ego-Density*	1876	32.39	30.08	0	100
Betweenness*	1876	3.55	8.68	0	100
Male	1876	0.76	0.43	0	1
Wealth	954	1.42	1.11	0	3
Banker	954	0.25	0.43	0	1
Immigrant	954	0.02	0.13	0	1
Engineer	954	0.04	0.19	0	1
Miner	954	0.08	0.27	0	1
Politician	954	0.23	0.42	0	1
Merchant	954	0.22	0.41	0	1
Liberal	954	0.09	0.28	0	1
Conservative	954	0.13	0.33	0	1
Migrant Family	954	0.025	0.15	0	1
Higher Education	954	0.025	0.15	0	1
Study Abroad	954	0.01	0.10	0	1

Note: This table presents descriptive statistics of the individuals in my sample.
*Measures for the complete network

Table 9: Cross section: Industrial Entrepreneurship and Social Networks. Negative Binomial

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(10b)
	Industrial involvement										
Betweenness	0.189***		0.159***	0.139**	0.176***	0.151**	0.144**	0.161***	0.147***	0.119**	0.166
	(0.058)		(0.059)	(0.057)	(0.061)	(0.061)	(0.060)	(0.060)	(0.056)	(0.059)	
Ego-density		-0.247**	-0.159	-0.158	-0.128	-0.151	-0.138	-0.164	-0.174	-0.139	-0.124
		(0.114)	(0.119)	(0.120)	(0.119)	(0.119)	(0.120)	(0.120)	(0.111)	(0.115)	
Banker				0.210**						0.153	0.165
				(0.092)						(0.099)	
Immigrant					0.166**					0.045	0.046
					(0.080)					(0.089)	
Engineer						0.113*				0.080	0.083
						(0.065)				(0.064)	
Miner							0.345***			0.280***	0.323
							(0.076)			(0.088)	
Politician								-0.031		-0.016	-0.016
								(0.107)		(0.098)	
Merchant									0.297***	0.241**	0.273
									(0.086)	(0.094)	
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. Coefficients from columns 1-10 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. Coefficients in Column 10b are the average rate of change in the 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: Panel: Industrial Entrepreneurship and Social Networks

	(1)	(1b)	(2)	(2b)	(3)	(3b)
			Industrial involvement			
	Neg Binomial		Poisson		Logit	
Betweenness	0.265***	0.303	0.163***	0.342	1.527***	0.357
	(0.034)		(0.008)		(0.220)	
Ego-density	0.240***	0.271	0.022*	0.251	0.415**	0.097
	(0.075)		(0.129)		(0.130)	
Individual FEs	Yes	Yes	Yes	Yes	Yes	Yes
Number of decades	8	8	8	8	8	8
Observations	898	898	898	898	898	898
Number of groups	114	114	114	114	114	114

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 in columns 1 and 2 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. Coefficients in column 3 are in log-odds units. Coefficients in Columns 1b, 2b are the average rate of change in the number of industrial firms founded for one standard deviation increase in the predictor variable, given the other predictor variables held constant. Coefficients in Columns 3b are marginal effects. Columns 1 and 3 report classical standard error estimates in parentheses. Column 2 reports robust standard error estimates. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 11: Panel: Correlation of Network Metrics

	Betweenness	**Ego-density**	**Degree**	**Closeness**	**Eigenvector**
Betweenness	1.00				
Ego-density	0.01	1.00			
Degree	0.30	0.38	1.00		
Closeness	-0.01	-0.02	-0.02	1.00	
Eigenvector	0.17	0.22	0.71	0.13	1.00

Note: This table presents the correlation matrix of the main network metrics.

Table 12: Panel: Industrial Entrepreneurship and Social Networks. Omitted Network Metrics Test

	(1)	(2)	(3)	(3b)	(4)	(5)	(6)	(6b)
	Industrial involvement							
	Neg Binomial				Logit			
Betweenness	0.265***	0.093**	0.099***	0.104	1.527***	0.915***	0.918***	0.21
	(0.034)	(0.037)	(0.037)		(0.220)	(0.219)	(0.220)	
Ego-density	0.240***	0.084	0.104	0.110	0.415***	0.059	0.059	0.013
	(0.075)	(0.079)	(0.081)		(0.130)	(0.150)	(0.150)	
Degree		0.536***	0.752***	0.078		1.040***	1.024***	0.234
		(0.072)	(0.100)			(0.204)	(0.242)	
Eigenvector			-0.198***	0.820			0.028	0.006
			(0.063)				(0.225)	
Individual FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of Periods	8	8	8	8	8	8	8	8
Observations	898	898	898	898	898	898	898	898
Number of groups	114	114	114	114	114	114	114	114

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 from columns 1-3 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. Coefficients from columns 4-6 are in log-odds units. Coefficients in Columns 3b are the average rate of change in the number of industrial firms founded for one standard deviation increase in the predictor variable, given the other predictor variables held constant. Coefficients in Columns 6b are marginal effects. Classical standard error estimates in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 13: Panel: Industrial Entrepreneurship and Social Networks. Negative Binomial. Reverse Causality Test

	Industrial involvement							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Betweenness	0.265***	0.099***						
	(0.034)	(0.037)						
Ego-density	0.240***	0.104						
	(0.075)	(0.081)						
Betweenness T-1			0.167***	0.066*				
			(0.036)	(0.036)				
Ego-density T-1			0.158**	0.099				
			(0.074)	(0.075)				
Betweenness T-2					-0.039	-0.137		
					(0.066)	(0.097)		
Ego-density T-2					0.058	0.033		
					(0.075)	(0.075)		
Betweenness T-3							-0.163*	-0.227**
							(0.095)	(0.108)
Ego-density T-3							-0.002	0.013
							(0.076)	(0.075)
Network Controls	-	Yes	-	Yes	-	Yes	-	Yes
Individual FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of Periods	8	8	8	8	8	8	8	8
Observations	898	898	835	835	740	740	616	616
Number of groups	144	144	144	144	144	144	143	143

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.

Table 14: Cross Section: Industrial Entrepreneurship and Social Networks. Negative Binomial. Market-Development Interaction

	(1)	(2)	(3)
	Industrial involvement		
Betweenness	0.203***	0.216***	0.161***
	(0.062)	(0.067)	(0.061)
Market Development	0.121**	0.134**	0.135**
	(0.059)	(0.062)	(0.062)
Betweenness x Market Development		-0.044	-0.052*
		(0.029)	(0.030)
Controls	Yes	Yes	Yes
Confounders	-	-	Yes
Observations	926	925	925

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 15: Politics Involvement in Industrial Entrepreneurship in Antioquia

Year	**Activity**	**Government Level**	**Details**
1840s-1900s	Schnapps	Regional	A legal monopoly per municipality assigned every 4 years to a private through a open bidding
1864	Chocolate	Regional	A legal monopoly for 10 years to a private
1864	Iron	Regional	Legal monopoly to a private
1885	Candles and stearic acid	Regional	A legal monopoly for 10 years to a private
1886-1900	Matches	National	Legal monopoly per department 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 sold in the interior
1912	Energy	Municipal	Legal monopoly to a private

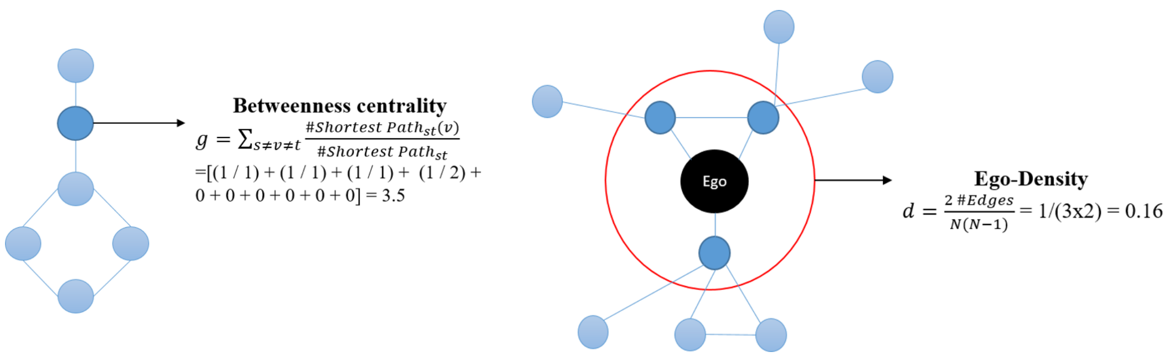
Note: This table summarizes the most relevant political interventions for promoting industrialization in this region during the period.
Source: Based on Mejía (2015b); Brew (1977)

11 Appendixes

11.1 Network metrics

There are several indexes of betweenness centrality and ego-density. I use the ones most frequently used, both of which are available in the igraph package of R and Python and are inspired in Barrat et al. (2004); Wasserman and Faust (1994); Brandes (2001); Freeman (1978)

Figure A1: Betweenness centrality and ego-density



Note: This figure presents two networks and the estimate 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 igraph package (see Csardi and Nepusz (2006))

11.2 Robustness checks

11.2.1 Alternative models

Extensive margin decision Most of the regressions of the paper exploit what you might consider 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 invested–or not–in industrial activities. For capturing this latter margin, I use a logistic model that estimates how the probability of being one of the founders of an industrial firm relates to her position in the social network.

Table A1 shows that the results of the estimation for the extensive margin decision are equivalent in qualitative terms to those of the intensive margin decision.

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

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(10b)
	Industrial involvement										
Betweenness	0.18***		0.18***	0.16**	0.19***	0.17**	0.16**	0.18***	0.16**	0.13*	0.007
	(0.061)		(0.065)	(0.067)	(0.065)	(0.067)	(0.067)	(0.065)	(0.067)	(0.073)	
Ego-density		-0.13	-0.041	-0.032	-0.023	-0.027	-0.006	-0.039	-0.042	0.006	0.000
		(0.120)	(0.128)	(0.128)	(0.127)	(0.130)	(0.129)	(0.129)	(0.128)	(0.130)	
Banker				0.19*						0.091	0.005
				(0.103)						(0.113)	
Immigrant					0.16*					0.018	0.001
					(0.093)					(0.102)	
Engineer						0.18**				0.15**	0.008
						(0.075)				(0.078)	
Miner							0.33***			0.25***	0.013
							(0.090)			(0.096)	
Politician								0.017		0.015	0.001
								(0.12)		(0.122)	
Merchant									0.31***	0.29***	0.015
									(0.100)	(0.106)	
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	954	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.

Intensive margin There are several alternatives for modeling counting data. For instance, Poisson and zero-inflated negative binomial models are commonly used in similar settings (Cameron and Trivedi, 2013). However, as I describe in Section 4.5, there are reasons to consider that a negative binomial model overperforms a Poisson model, mostly because we face overdispersed data. Similarly, a Vuong test suggests that a regular negative binomial overperfomes a zero-inflated one. In any case, Table A2 shows how the results from both of these approaches offer quite similar results to the ones of Table 9.

Table A2: Cross section: Industrial Entrepreneurship and Social Networks

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Industrial involvement							
	Poisson				Z.I. Negative Binomial			
Betweenness	0.188***		0.166***	0.119***	0.156**		0.128*	0.113*
	(0.041)		(0.041)	(0.046)	(0.063)		(0.065)	(0.067)
Ego-density		-0.263**	-0.168	-0.126		-0.238**	-0.159	-0.154
		(0.110)	(0.111)	(0.112)		(0.116)	(0.120)	(0.122)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Confounders	-	-	-	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. 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.

Some authors consider ordinary least squares estimates to be reasonable approximations for counting data analysis. Table A3 shows that OLS results are also similar to the ones of Table 9.

Table A3: Cross section: Industrial Entrepreneurship and Social Networks. OLS

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Industrial involvement									
Betweenness	0.088**		0.085**	0.079**	0.086**	0.081**	0.076**	0.084**	0.078**	0.065*
	(0.036)		(0.036)	(0.036)	(0.037)	(0.036)	(0.035)	(0.036)	(0.036)	(0.034)
Ego-density		-0.044*	-0.014	-0.014	-0.011	-0.011	-0.004	-0.014	-0.014	-0.005
		(0.023)	(0.021)	(0.021)	(0.021)	(0.021)	(0.022)	(0.021)	(0.021)	(0.021)
Banker				0.048*						0.025
				(0.026)						(0.027)
Immigrant					0.024					-0.025
					(0.022)					(0.028)
Engineer						0.059*				0.050
						(0.030)				(0.033)
Miner							0.103**			0.089*
							(0.041)			(0.049)
Politician								0.004		-0.001
								(0.034)		(0.034)
Merchant									0.081***	0.066**
									(0.030)	(0.031)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
Observations	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. Coefficients from columns 1-10 are the expected change in the 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.

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

11.2.2 Time effects

The incidental parameter problem in non-linear models with multiple effects makes it inappropriate to include time fixed effects in the main specification (see Fernández-Val and Weidner, 2016). To deal with concerns on particular time-related conditions, in Table A4 I replicate the main dynamic specification excluding every decade sequentially. The results remain, showing that they are not driven by temporal particularities.

Table A4: Panel: Industrial Entrepreneurship and Social Networks. NB. Time Effects Test

	(¬1850)	(¬1860)	(¬1870)	(¬1880)	(¬1890)	(¬1900)	(¬1910)	(¬1920)
	Industrial involvement							
Betweenness	0.257***	0.250***	0.243***	0.248***	0.289***	0.311***	0.296***	0.338***
	(0.033)	(0.033)	(0.033)	(0.034)	(0.037)	(0.040)	(0.059)	(0.050)
Ego-density	0.294***	0.234***	0.233***	0.226***	0.233***	0.267***	0.224**	0.217**
	(0.078)	(0.078)	(0.075)	(0.077)	(0.079)	(0.083)	(0.093)	(0.093)
Network Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of decades	7	7	7	7	7	7	7	7
Observations	835	803	775	745	743	766	727	766
Number of groups	144	144	144	139	141	143	135	135

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.

OLS estimates, which enables to incorporate consistent time fixed effects, can be used as an approximation for corroborating the previous fact. Table A5 indicates that despite the significance of time dummies, the relations between social network position and industrial entrepreneurship are still present.

Table A5: Panel: Industrial Entrepreneurship and Social Networks. OLS

	(1)	(2)	(3)	(4)
	Industrial involvement			
Betweenness	0.163***	0.145***	0.118***	0.105***
	(0.008)	(0.008)	(0.008)	(0.008)
Ego-density	0.022***	-0.004	-0.010	-0.029***
	(0.008)	(0.010)	(0.008)	(0.009)
1860.t			-0.004	-0.006
			(0.015)	(0.015)
1870.t			0.001	-0.004
			(0.015)	(0.015)
1880.t			0.028*	0.024
			(0.015)	(0.015)
1890.t			0.045***	0.043***
			(0.015)	(0.015)
1900.t			0.106***	0.102***
			(0.016)	(0.016)
1910.t			0.367***	0.362***
			(0.020)	(0.020)
1920.t			0.474***	0.470***
			(0.023)	(0.023)
Network Controls	-	Yes	-	Yes
Individual FEs	Yes	Yes	Yes	Yes
Number of decades	8	8	8	8
Observations	10,171	10,171	10,171	10,171
Number of groups	1,792	1,792	1,792	1,792

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 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.

11.2.3 Measurement error

As described in Section 6.3 there are two types of potential biases in the construction of the network: selection of edges, selection of ties.

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 the 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 will be related to an attenuation bias in my estimation. Therefore, coefficients in Table 9 must be interpreted as lower bounds of the real effects.

Most importantly, a similar kind of bias could have arisen 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 9, this implies that those seeds would be better connected by construction. As they 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 9 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 A10). The results are virtually the same in all three subsamples and to those of Table 9. This offers confidence that my results are not being driven by a bias originated in the selection of the snowball-sample seeds.

Table A6: Panel: Industrial Entrepreneurship and Social Networks. NB. Seeds' exclusion Test

	(1)	(2)	(3)	(4)	(5)	(6)
	Industrial involvement					
	No seeds		No seeds' family		No bankers 1888	
Betweenness	0.182***	0.124**	0.159***	0.119**	0.195***	0.156**
	(0.059)	(0.058)	(0.059)	(0.059)	(0.066)	(0.069)
Ego-density	-0.182	-0.142	-0.159	-0.139	-0.149	-0.162
	(0.115)	(0.115)	(0.119)	(0.115)	(0.128)	(0.121)
Confounders	-	Yes	-	Yes	-	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	951	951	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 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 A7 shows how including these sort of controls do not change the main results. Moreover, these controls are not significant and positively correlated with industrial involvement, what suggest that there is not even such a literature bias towards industrial entrepreneurs.

Table A7: Panel: Industrial Entrepreneurship and Social Networks. NB. Historiography Bias Test

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
				Industrial involvement				
Betweenness	0.169***	0.127**	0.173***	0.130**	0.158***	0.119**	0.158***	0.119**
	(0.0606)	(0.0603)	(0.0611)	(0.0611)	(0.0588)	(0.0588)	(0.0588)	(0.0590)
Ego-density	-0.167	-0.145	-0.163	-0.141	-0.155	-0.130	-0.154	-0.128
	(0.119)	(0.115)	(0.119)	(0.115)	(0.119)	(0.115)	(0.120)	(0.115)
GoogleI	-56.50**	-58.57						
	(28.49)	(71.71)						
GoogleII			-7.962**	-7.801				
			(3.729)	(6.014)				
GoogleIII					0.289	0.442		
					(0.357)	(0.386)		
GoogleIV							0.349	0.542
							(0.394)	(0.438)
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. Industrial involvement is measured as the number of 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 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 9 might have been biased.

Three strategies are used to minimized this potential bias:

First, as Van Meter (1990); 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 Becker (1970); 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 A8 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 A8: 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 A9 shows that the individuals from the first and second component of the sample differ in the expected ways. The second component's individuals have in average lower betweenness centrality and ego-density. They are also less involve in industrial entrepreneurship. However, that difference is not statistically significant.

Table A9: Comparisons of the components of the sample

	Second component	**First component**	**Difference**
Industrial	0.11	0.12	-0.01
Industrial involvement	0.19	0.21	-0.02
Betweenness	0.3	6.84	-6.54***
Density	40.64	45.21	-4.58**

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 A10: Cross section: Industrial Entrepreneurship and Social Networks. NB. Sample Bias Test

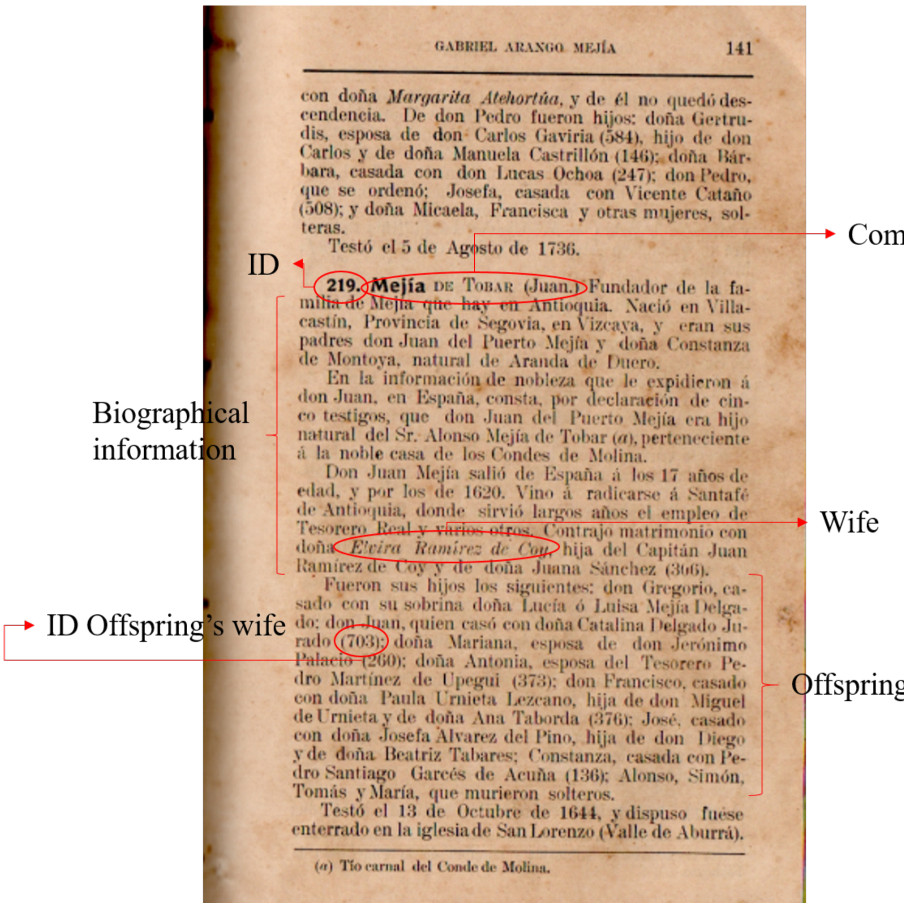
	First component	Full Sample
Betweenness	0.183***	0.247***
	(0.065)	(0.067)
Ego-density	-0.151	0.055
	(0.116)	(0.099)
Male	2.803***	2.848***
	(0.455)	(0.448)
Observations	954	1,358

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. 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.

11.3 Examples of Primary Sources

11.3.1 First Sample Component

Figure A2: Sample of Genealogical Study. Gabriel Arango's Genealogies. Mejia Family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con doña *Margarita Atehortúa*, y de él no quedó descendencia. De don Pedro fueron hijos: doña Gertrudis, esposa de don Carlos Gaviria (584), hijo de don Carlos y de doña Manuela Castrillón (146); doña Bárbara, casada con don Lucas Ochoa (247); don Pedro, que se ordenó; Josefa, casada con Vicente Cataño (508); y doña Micaela, Francisca y otras mujeres, solteras.

Testó el 5 de Agosto de 1736.

219. Mejía de Tobar (Juan.) Fundador de la familia de Mejía que hay en Antioquia. Nació en Villacastín, Provincia de Segovia, en Vizcaya, y eran sus padres don Juan del Puerto Mejía y doña Constanza de Montoya, natural de Aranda de Duero.

En la información de nobleza que le expidieron á don Juan, en España, consta, por declaración de cinco testigos, que don Juan del Puerto Mejía era hijo natural del Sr. Alonso Mejía de Tobar (*a*), perteneciente á la noble casa de los Condes de Molina.

Don Juan Mejía salió de España á los 17 años de edad, y por los de 1620. Vino á radicarse á Santafé de Antioquia, donde sirvió largos años el empleo de Tesorero Real y varios otros. Contrajo matrimonio con doña *Elvira Ramírez de Coy*, hija del Capitán Juan Ramírez de Coy y de doña Juana Sánchez (366).

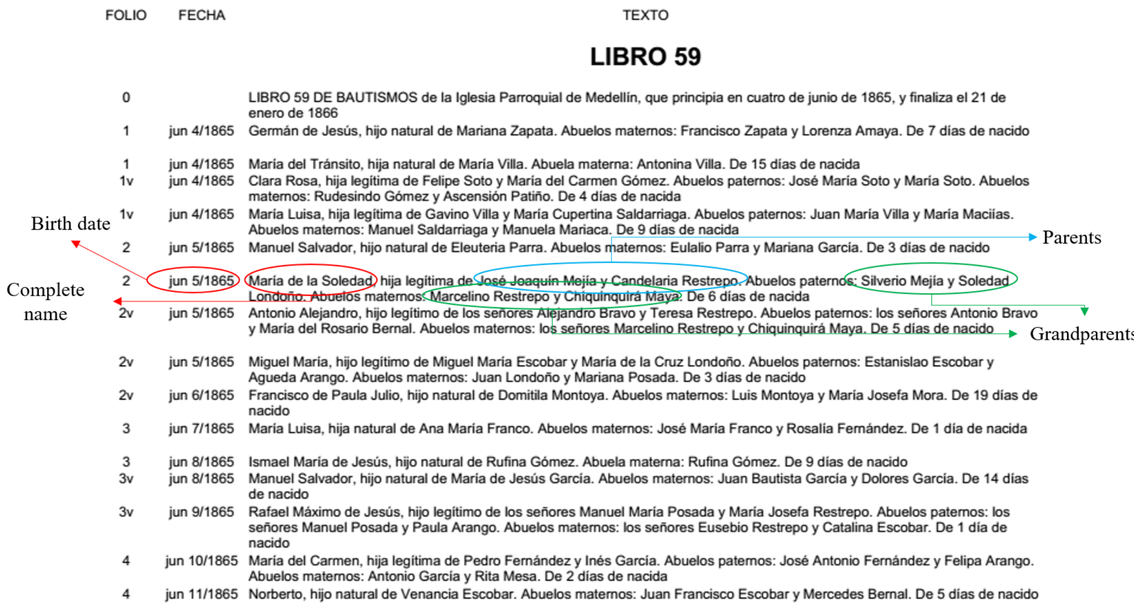
Fueron sus hijos los siguientes: don Gregorio, casado con su sobrina doña Lucía ó Luisa Mejía Delgado; don Juan, quien casó con doña Catalina Delgado Jurado (703); doña Mariana, esposa de don Jerónimo Palacio (260); doña Antonia, esposa del Tesorero Pedro Martínez de Upegui (373); don Francisco, casado con doña Paula Urnieta Lezcano, hija de don Miguel de Urnieta y de doña Ana Taborda (376); José, casado con doña Josefa Alvarez del Pino, hija de don Diego y de doña Beatriz Tabares; Constanza, casada con Pedro Santiago Garcés de Acuña (136); Alonso, Simón, Tomás y María, que murieron solteros.

Testó el 13 de Octubre de 1644, y dispuso fuése enterrado en la iglesia de San Lorenzo (Valle de Aburrá).

(*a*) Tío carnal del Conde de Molina.

Note: Sample of a genealogical study. These were works, usually published, that systematize the genealogical origins of several lineages. This sample presents the information of the first Mejia that arrived to Antioquia. It includes his complete name, the complete name of his wife and offspring. It also includes additional 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 source. I used several genealogies in addition of Arango (1911). All of them share similar attributes.

Figure A3: Sample of Baptism Records. Medellin, book 59, June 1865-January 1866.

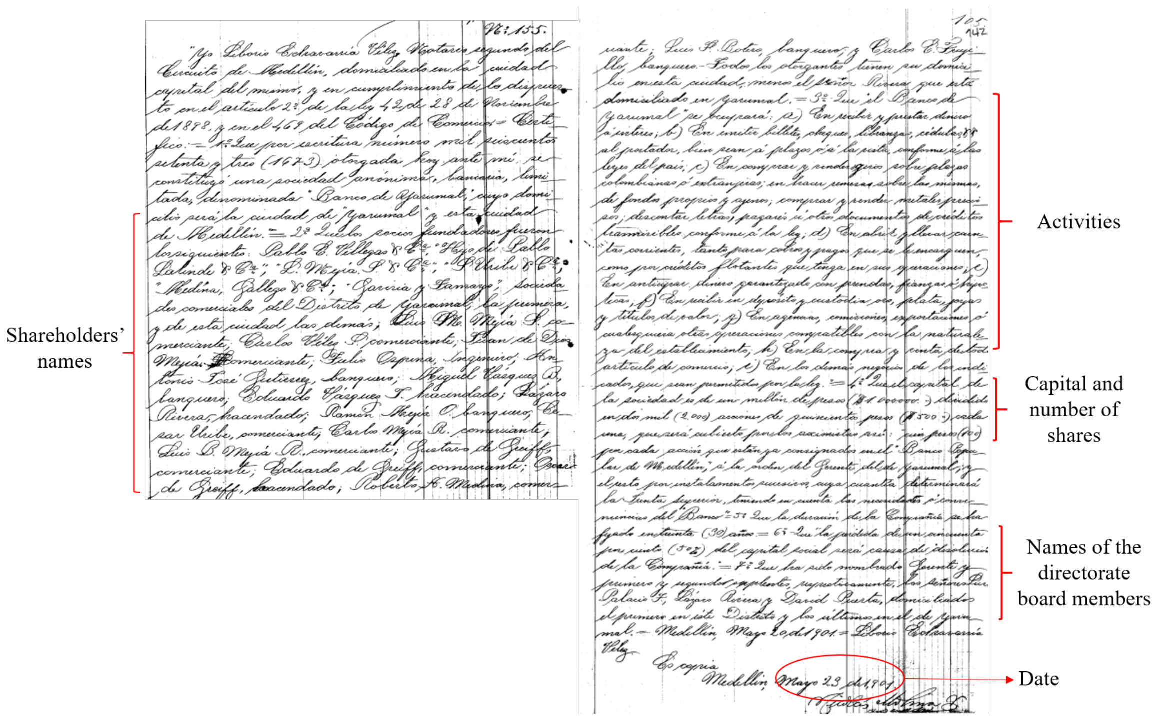


LIBRO 59

FOLIO	FECHA	TEXTO
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 Maciias. 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

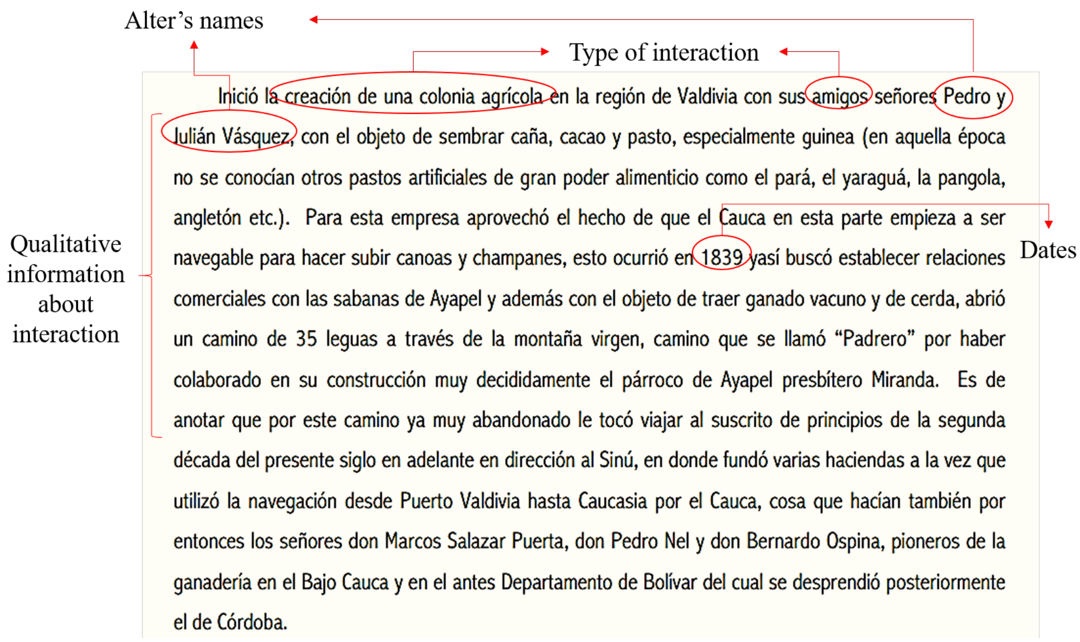
Note: Sample of a baptism book. This figure presents the information of one book of baptism. In this books, priests recorded the names of every child baptized, in addition to the names of their parents, and grandparents. I have a non-random sample of books from several locations.

Figure A4: Sample of Constitutional Document. Banco de Yarumal



Note: Sample of constitutional document. This figure presents the constitutional document of Banco de Yarumal. It includes the name of every shareholder of the company, the activities performed by the company, 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 of this document.

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

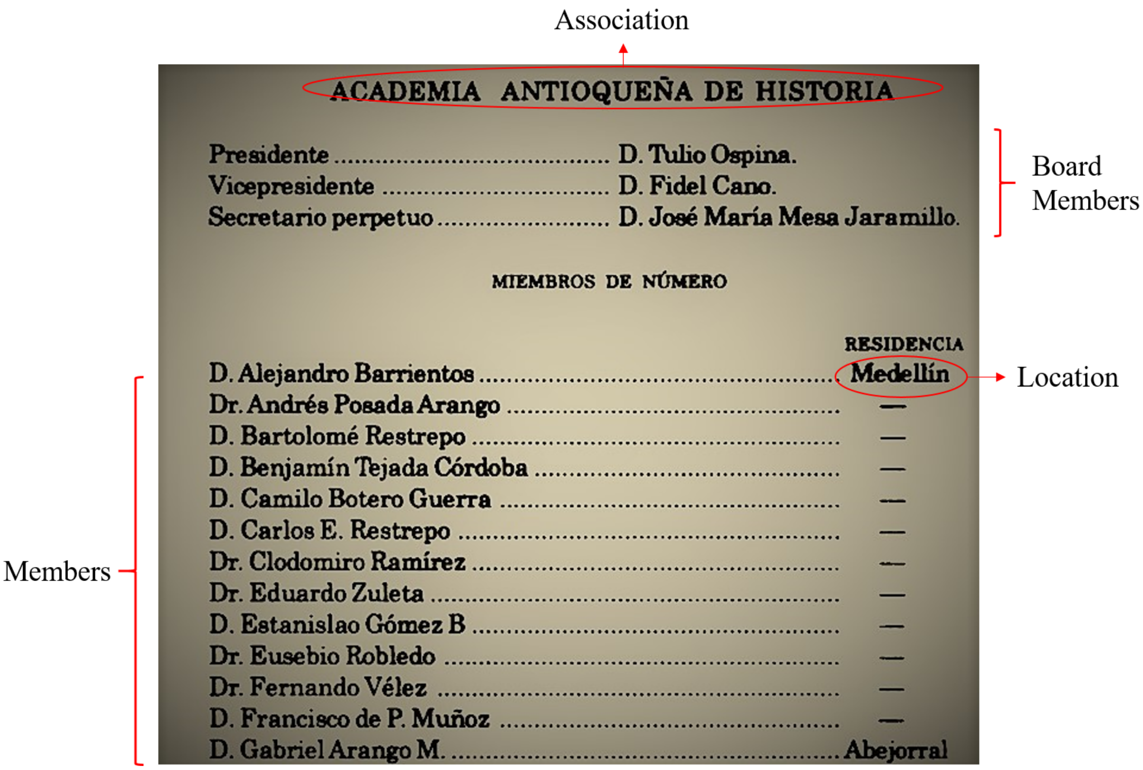


Inició la creación de una colonia agrícola en la región de Valdivia con sus amigos señores Pedro y Julián Vásquez, con el objeto de sembrar caña, cacao y pasto, especialmente guinea (en aquella época no se conocían otros pastos artificiales de gran poder alimenticio como el pará, el yaraguá, la pangola, angletón etc.). Para esta empresa aprovechó el hecho de que el Cauca en esta parte empieza a ser navegable para hacer subir canoas y champanes, esto ocurrió en 1839 y así buscó establecer relaciones comerciales con las sabanas de Ayapel y además con el objeto de traer ganado vacuno y de cerda, abrió un camino de 35 leguas a través de la montaña virgen, camino que se llamó "Padrero" por haber colaborado en su construcción muy decididamente el párroco de Ayapel presbítero Miranda. Es de anotar que por este camino ya muy abandonado le tocó viajar al suscrito de principios de la segunda década del presente siglo en adelante en dirección al Sinú, en donde fundó varias haciendas a la vez que utilizó la navegación desde Puerto Valdivia hasta Caucasia por el Cauca, cosa que hacían también por entonces los señores don Marcos Salazar Puerta, don Pedro Nel y don Bernardo Ospina, pioneros de la ganadería en el Bajo Cauca y en el antes Departamento de Bolívar del cual se desprendió posteriormente el de Córdoba.

Note: Sample of an entrepreneurial narrative. This figure presents a fragment of Echavarria, who shares his memories of the business activity of the region. The attributes and the information available in this type of sources vary significantly. However, it is rich and qualitative information about the content of ties and attributes of individuals.

11.3.2 Second Sample Component

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



ACADEMIA ANTIOQUEÑA DE HISTORIA

Presidente .... D. Tulio Ospina.
Vicepresidente .... D. Fidel Cano.
Secretario perpetuo .... D. José María Mesa Jaramillo.

MIEMBROS DE NÚMERO

	RESIDENCIA
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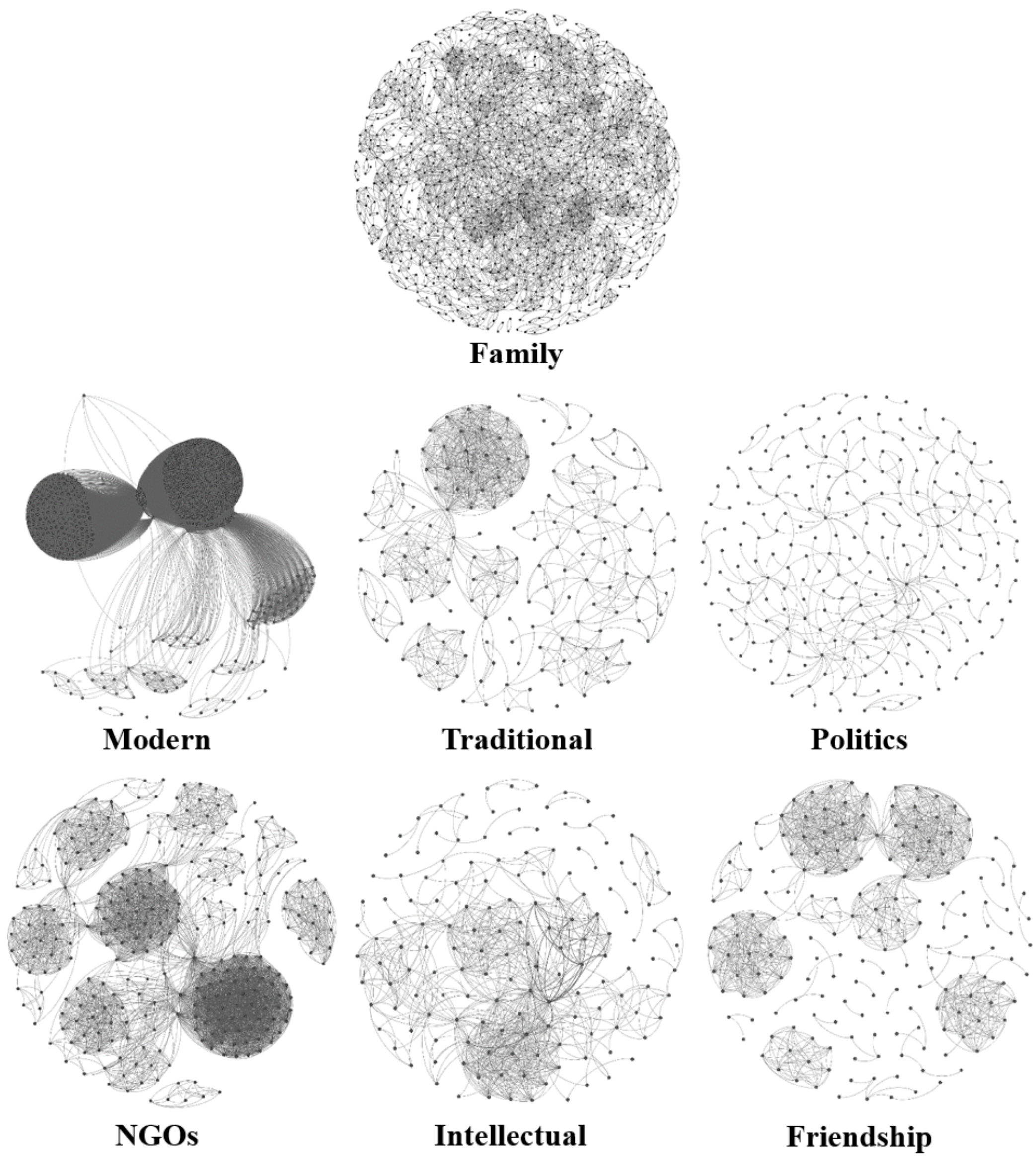
Dr. Andrés Posada Arango	—
D. Bartolomé Restrepo	—
D. Benjamín Tejada Córdoba	—
D. Camilo Botero Guerra	—
D. Carlos E. Restrepo	—
Dr. Clodomiro Ramírez	—
Dr. Eduardo Zuleta	—
D. Estanislao Gómez B	—
Dr. Eusebio Robledo	—
Dr. Fernando Vélez	—
D. Francisco de P. Muñoz	—
D. Gabriel Arango M.	Abejorral

Note: Sample of elite's associations. This figure presents a fragment of the list of the members of the Academy of History.

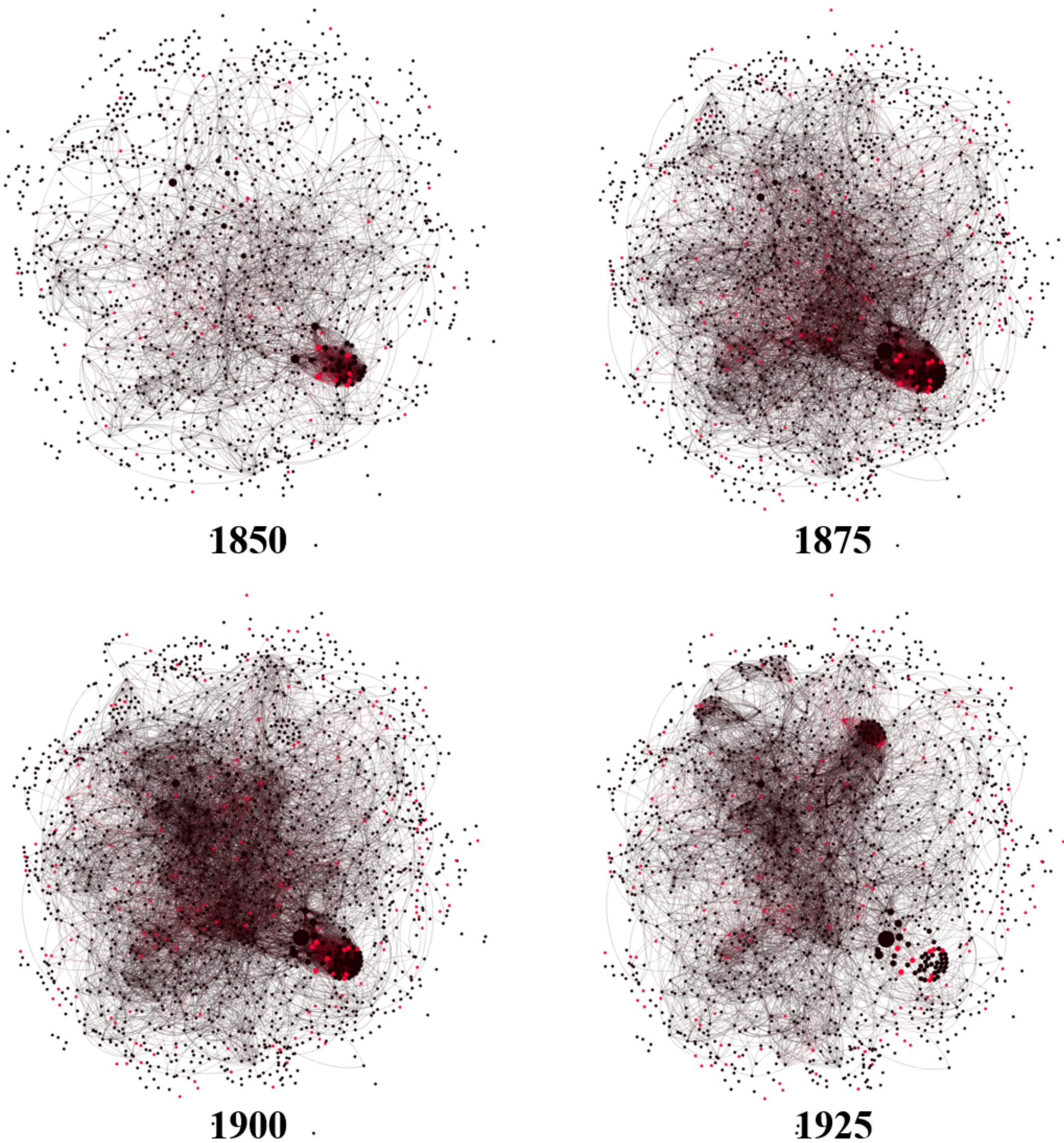
11.4 Networks

Figure A7: Static Networks' Graphs



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 A8: Static Networks' Graphs. Complete Network



Note: This figure presents the graph of the each static network. 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.