The Structure and Dynamics of Migration Patterns in 19th-century Northern France

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Abstract

Spatial and relational patterns of intensive rural-urban migration are a major concern in social sciences. We reconstitute migration areas and explain their path-dependent changes through an innovative and easily replicable research strategy. Focusing on the rapid urbanization of 19th-century Northern France, we analyze the long-neglected, yet non-random patterns of movement between villages and explain the exceptionally slow pace of French rural out-migration. The techniques inspired by network analysis complement standard models used in economic geography and allow us to identify the enduring channels of preferential migration between villages as well as the impact of changing socio-economic opportunities. The social differentiation among the possibilities to migrate, along with the interactions between marriage and work-related movements, produce multivariate models of migration field transformations.

The spatial patterns and relational aspects of migration in the context of rural depopulation, urbanization, and trans-border movements are of important concern to social scientists (e.g., geographers, sociologists, economists, and especially to today's development specialists and historians) seeking to understand the macro and micro impacts of the Industrial Revolution. In this paper, we present an innovative and easily replicable research strategy. It initially allows us to describe the preferential routes used either to migrate to the metropolis or to develop alternative, intra-rural migration strategies. In addition, we are able to explain how these routes changed in a path-dependent way from generation to generation. From a substantive point of view, this enables us to make sense of the long-neglected, yet non-random patterns of movement between villages, which in turn helps to explain a peculiar feature of French history: the slow pace of rural out-migration. From a methodological point of view, we show that fairly recently developed techniques of network analysis, especially the integrative use of blockmodeling and actor-oriented dynamic modeling, provide important complements to the standard methods used in economic geography in order to model a variety of flows, including migration.

In the last decades, the social sciences have been increasingly paying attention to the relational aspects of migration that have been either included in multivariate, quantitative models (e.g., Palloni *et al.*, 2001) or described in more qualitative, micro studies of families or places (e.g., Fertig, 1998; Rosental, 1999, 2006; Takai, 2001). These studies generally focus on the decision to migrate and its collective aspects — such as the influence of relatives or neighbors having already migrated ("primary migrants"). This approach emphasizes the role of information on distant opportunities which can be provided by correspondence with such "pioneers" (Hvidt, 1980). This line of research has been enhanced by new methodological opportunities such as panel studies, genealogical reconstitution, event history analysis and multi-level modeling (e.g., Dribe and Lundh, 2005; Courgeau, 2007; Bonneuil, Bringé, and

Rosental, 2008); it had been pioneered in the 1950s by the Swedish geographer Torsten Hägerstrand (1916-2004; Hägerstrand, 1957).

However, Hägerstrand's hypotheses and results were not only expressed through tables and models, but also through maps; he was not only interested in the relational aspects of the binary decision to migrate or not, but also in the choice of a specific destination in terms of distance and direction. This can be viewed as a more spatial view on migration, which in turn leads to historical questions such as: how is it that spatial patterns of migration are often shown to be quite enduring, forming a slowly changing social structure or institution which constrains the direction of future moves? In 1889, Ravenstein had already identified such phenomena, writing that "migratory currents flow along certain well-defined geographical channels." Nevertheless, what we can deem a spatial tradition in the study of migration has not become dominant in the field when compared to a more statistical tradition (Rosental, 1997). This is probably due, in part, to methodological difficulties in representing and understanding the complex data structure involved if one were to study not only the in-migration or out-migration of one place (what we could consider to be an ego-centered migration field in terms of network analysis), but all the movements between a set of places (a complete network). The present paper shows that by using tools borrowed from social network analysis along with more classical geographical modeling, we can test hypotheses such as Hägerstrand's in regard to the structure of migration fields as well as their evolution.

Our empirical field of study is 19th-century Northern France. We have chosen it for its experimental value. First, it was one of the only areas in 19th-century France that was exposed to brutal industrialization and urbanization—as has been the case in England before and in Germany thereafter. Urbanization towards booming towns or cities of this area has often been studied (e.g., Pétillon, 2006), yet there has been almost no research on what went on in the countryside during this process—as if it had been entirely passive and subject to urban attraction. Migrations between small, rural villages, despite their high numbers, have been dismissed by some scholars as a quasi-random "micro-mobility" (Poussou, 1970, 2002). We are not satisfied with this conclusion and want to test if these decisions to migrate were actually random or if they followed preferential channels. How important were preferential relationships between villages in this area during the rise of urbanization? Did rural migration flow go through pre-existing channels, or did urbanization suddenly create new paths of mobility? Did it shatter intra-rural preferential relationships or leave them unchallenged? In order to answer these questions, we devised our data collection so as to be able to compare migration fields at three different points in time—separated by one or two generations—in the beginning, middle and end of the century.

Second, there was not one main point of destination within the region, but several: three booming cities (Lille, Roubaix, Tourcoing, the former also being an administrative capital city)[1] as well as several immigration towns. How were the flows segmented between those destinations? Third, this region was among the few in France that were divided by a linguistic boundary: the Eastern (and generally more urban half) spoke French, while the Western (and generally more rural half) spoke Flemish. These two peculiarities make the North particularly relevant to test a multivariate model of migration, including likely preferences for "similar" places along with the attraction of economic opportunities. Fourth, the North was one of the first two massive regions of foreign immigration (along with the South East, which attracted many Italian migrants); we will check to what extent internal and external migration were competing or complementary.

Finally, however exceptional compared to the rest of the country, the case of our region may shed light on a major macro-historical issue: why did France experience a rate of rural

[1] See the distribution of European cities over 100,000 inhabitants: the map displays their slow increase in 19th century France and the peculiarity of Lille, Roubaix and Tourcoing as three big cities concentrated in the same area (Moch 1992, p. 126).

out-migration that was much slower and progressive than in other industrialized, Northwestern European countries[2]? Urban population caught up to rural population as late as 1928 and really took off after 1945—several decades after most neighboring countries and even later in comparison to England. This is generally explained by the fact that most of the French peasants were reluctant to move because many of them were small land owners. However, our region provides a case where most of the agricultural workforce was composed of wage-earners (servants or day-laborers). This might explain why urbanization had a particularly fast pace. We will nevertheless show that, even in this somewhat exceptional case, there were alternative migration strategies involving moves between familiar places and likely to have contributed to slowing down the rhythm of out-migration.

The remainder of this paper first gives a more thorough presentation of the available strategies for modeling migration between places as well as some of Hägerstrand's ideas that our method enables us to test (Part 1). We then lay out our case study, our data and our specific hypotheses (Part 2). After briefly presenting the main features of migration in our region (Part 3), we move on to describe the local and global patterns of migration flows and their evolution (Part 4) which allows us to devise a multivariate dynamic model (Part 5). The final part of the paper is devoted to a substantive discussion of the conclusions formulated by the previous parts (Part 6).

1. Migration, space, time and social networks

Classical models of migration (e.g., Taylor, 1975)—such as those developed by Ravenstein at the end of the 19th century and later by Zipf and Stouffer—generally rely on

[2] In 1913, the rate of urban population in France reached 39.5% similar to that of Spain and Swizerland and somewhat less than that Italy, while it was 58.0 in Belgium, 51.0 in Germany, 51.3 in the Netherlands and 69.7 in the United Kingdom (Bairoch, 1998, 221).

aggregate data (the total of flows between places). Zipf may be considered to be the pioneer in the so-called "gravitational" models that were inspired by mechanics and, to some extent, were similar to the "push and pull model" developed from the 1920s onwards. They model migration flows as dependents on geographic distance (seen as a cost) and total population of the places involved (at best seen as a proxy for job opportunities). Stouffer added to this basic idea a more realistic, yet difficult to measure, conception of space through the notion of "intervening opportunities," describing the amount of economic opportunities encountered between the places of origin and destination.

Rather simple models of a general "law of migration," such as the one encapsulated in the gravitational model, are still heuristically useful only capture a part of the phenomenon. The study of flow matrices has benefited from increasing computing power in the last decades, which allowed the use of spatial auto-correlation techniques (e.g., Anselin, 1995; Tobler, 1995). This allows us to consider the influence of clustering phenomena as well as the effects of physical distance (e.g., transportation costs) and population (or other measures of size) based on boundaries (political, linguistic; e.g., Cattan, Grasland, and Rehak, 1996). Notwithstanding these advances, it is still difficult to include many different explanatory variables in such models as they cannot capture some specifically relational phenomena, such as the tendency of some migration flows to become symmetrical.

Can we make sense of the "residuals" of these more or less classical models? Hägerstrand already considered that they were perhaps more interesting than the "laws of migration" themselves. His research provides many hypotheses that the currently available techniques enable us to test. Taking empirical refutations seriously, he tried to understand why pairs of cities or countries actually exchanged more (or fewer) migrants than predicted by Zipf's or Stouffer's models. He particularly insisted on "deviations from the 'inverse-distance rule'" (1957, p. 126), even arguing that this rule could be nothing more than a limit-case of the exceptions. His vision of migration was derived from his more general interest in diffusion processes. Long before social network analysis was applied to the study of individual decisions to migrate, he emphasized personal contacts and the circulation of information (rather than macro phenomena such as urbanization) in a more systematic way. More precisely, he considered that macro-economic processes, as formalized by Stouffer, were only a background. For example, they help to understand why poor areas generally produced migrants towards wealthy areas; however, they are unable to explain why some expected flows of mobility did not occur. Better migration models should account for the reason that, all things being equal, migrants starting from a town/country A did or did not go to a town/country B located at a given distance and providing the same opportunities.

Hägerstrand's unit of analysis is therefore the set of possible destinations from a given place of origin, which he called "migration field" or "migration area." Using the exceptional Swedish nominative data, he empirically demonstrated the enduring patterns of migration fields over time—sometimes from the 1780s to the 1950s. While describing migration fields as "a chain of connected events" (*ibid*., p. 131) instead of a static structure, he insisted on their relative inertia, explained by a path-dependency mechanism rooted in his relational view of migration:

> "It seems as if irregularities, resulting partly from transportation conditions of former times and partly from other 'historical' factors, have created a network of social contacts, which tend to conserve a 'bias' in the migration frequencies even when changed conditions no longer limit travel. It seems not unlikely that once they have arisen, irregularities in the shape of migration fields have a tendency to perpetuate themselves because migrations at any given time are *dependent* on preceding migrations." (Hägerstrand, 1957, p. 130)

Path-dependency, however, should not be confused with stability: migration is constrained by previous migration, but migration flows are in fact changing. Hägerstrand used ingenious maps and sometimes even hand-made simulations[3] (Hägerstrand, 1965) to identify the precise shape of and changes in migration fields. He put emphasis on directional asymmetries (considering space as "heterotropic" rather than "isotropic"), cumulative processes, and diffusion from the experience of pioneer migrants. For Zipf and even Stouffer, space was "isotropic" because it was in fact reduced to economic and demographic variables: if a destination place B suddenly gained (resp. lost) half of its population, its attraction increased (resp. declined) proportionately. On the contrary, for Hägerstrand, each place in a migration field was part of specific patterns shaped by migration history. All things being equal, a migrant from A would go to B rather than C according to the respective migratory history between the two pairs (A,B; A,C). Previous flows in the opposite direction could also play a role, as Hägerstrand's studies of parish migration fields uncovered the fact that many if not most of the migratory relationships between places were symmetrical (in-migration more or less balancing out-migration; net fluxes being comparatively negligible).

Finally, the mechanisms described by Hägerstrand and his followers integrated micro and macro processes in a very impressive way. If pioneers from village A choose a preferential destination B, they thus develop human and economic relationships between A and B (marriage, commercial exchanges). Over time, those relationships may be institutionalized, e.g., influence the creation of roads or railroads. Institutions and personal networks then combine their influences to intensify the flows of mobility between A and B (Dahl, 1957).

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[3] He randomly simulated pioneer migrants and applied diffusion processes. Historians inspired by his hypotheses could afterwards test them thanks to the exceptional Swedish nominative registers. Rice and Ostergren, 1978 identified the first migrant sent to the US from a Swedish micro-region in the mid 19th century, and demonstrated how the subsequent snowball process was initiated by this pioneer's relatives and close neighbors. See also Akerman *et al.*, 1977.

These pioneering empirical studies nevertheless had one important limit: they only studied the ego-centered migration fields of one village or parish. Generalizations could of course be questioned, as for any case study; more specifically, this concentric approach fails to consider the interaction between neighboring migration fields. One knows with which towns or countries a place A exchanges migrants, but without having any idea of the aggregate structure of A, B, C … N migration areas, A-N being places located in the same region or continent.

Our paper thus aims to integrate both the robust bases of classical modeling (the fact that distance and size have obvious effects on migration which should be taken into account) and the intuitions of Hägerstrand and his followers (the existence of more complex spatial patterns, the significance of symmetry, and questions about path-dependency) while studying a complete network of migration. In addition, we use structural concepts inspired by social network analysis, such as transitivity, in order to test some of the mechanisms currently discussed (but not always clearly specified) in migration studies, such as "chain migration." We do this by first estimating a simple gravitational model for observed flows and then consider the residuals of this model as a matrix of over- or under-attractions between places. Network analysis methods help us to describe the local and global patterns in this matrix and to model their dynamics. Our underlying idea is close to that of network studies dealing with other flows, such as those of international trade (Smith and White, 1992); however, we do not limit ourselves to the static blockmodeling of a matrix of flows (Lemercier and Rosental, 2000). To our knowledge, network analysis has never been used in this way to study migration[4]. Although Hägerstrand himself was aware of Moreno's sociometric research, he criticized structural network analysis as too static—which was quite true at that time.

We thus integrate two separate traditions in migration studies: the statistical modeling of flow matrices and the socially and historically embedded description of migration fields. This

[4] See an application of factor analysis in Johnston and Perry, 1972.

research strategy is easily applicable to any data on migration flows between places, although it will provide more interesting results when separate data on various characteristics of the places are also available—which is the case for our study of 19th-century Northern France.

2. The case study

Location

As we are especially interested in "routine" migration between villages and want to verify the importance of macro phenomena, such as rural migration and industrialization, we deliberately chose to study one of the French regions in which they were the strongest in the 19^{th} century. Our sample consists of 75 adjacent *communes*[5] (the finest administrative unit established during the French Revolution and has since only been slightly modified) situated in a ca. 50 km x 20 km zone West of Lille, along the French-Belgian border[6] (Figure 1). The small size of the French *communes* allows short-distance migration to be detected from administrative sources. Several factors allowed us to consider that the *commune* was a reasonably good proxy for the community where mechanisms of interest were at play.

Since the French Revolution, that had created *communes* by reducing the attributes of the parishes; the *commune* has been the most important and well-known administrative, political and social unit for most French citizens. It governs the main events in their lives: birth, marriage, and death certificates are declared and recorded at the town hall, which is also the

[5] Data for Le Doulieu are missing, as are those for Haverskerque in the first period and Bois-Grenier in the first two periods (this last *commune* was created just before the second period, so that we could only use the third-period data, as we wanted to consider it both as a place of birth and place of dwelling).

[6] Belgian migration to our region, which was important and generally shaped by the linguistic boundary, has been studied by Rosental, 1996. We could not directly include Belgian villages in our study of the migratory field, as marriage records were a bit different in Belgium and, more importantly, administrative units were much larger, thus giving a quite different view of local migration.

place where civil marriages (the only official form of marriage since the Revolution) are celebrated. For most of the 19th century, electing the mayor has been the key political process in rural areas. Running the *communes* directly involved and confronted all local networks since the most important issues having to do with private property (road access for instance) were decided and managed at that scale (Karnoouh, 1975). *Communes* also provided welfare, either directly in times of crisis, or indirectly: when a local citizen died, for instance, the mayor could provide his or her heirs with a certificate testifying that he or she was poor enough so that they would be exempt from succession tax payment. Most charitable institutions were also located at this scale (Marec, 2002).

Moreover, in rural villages, the commune coincided with other major institutions such as the (Catholic) parish. Even though France was less concerned with the "religious local welfare model" than Northern Europe, this unit was instrumental in building up the community—particularly in the North of France, which remained one of the most Catholic areas after the Revolution. Masses and markets were opportunities to regularly gather the part of the population that lived in separate hamlets on *commune* territory. Important national or religious holidays were also organized and celebrated at that scale. *Communal* schools, whose number increased throughout the 19th century, created lifelong generation peers, as did military conscription, a major political institution which concerned most males and brought about strong local ritualization (Bozon, 1981).

Finally, the *commune* was to a wide extent a residential unit. In the North of France, most inhabitants lived in the village that was the administrative centre of the *commune*—contrarily to some areas with a sparse population in Western France where communal limits were somewhat abstract (Wylie, 1968). *Commune* was hence experienced as a small political unit which, to some extent, distinguished itself from the outside world (Karnoouh, 1972). Big cities kept this political dimension for their citizens, but were more fragmented by *quartiers* (neighborhoods) from a sociological standpoint. This was particularly true for Lille, the main regional metropolis. Our data does not provide the exact address of urban dwellers, which makes us unable to measure potential concentrations of migrants within the big cities; a phenomenon which, according to the relevant literature, should not be exaggerated anyway (Ogden and Winchester, 1975).

Having thus defined our basic observation unit, we can go back to the general morphology of the region under study. Figure 2 is an extract from the famous Cassini map of France drawn in the 18th and 19th centuries[7]. It shows that our quite flat region was densely innervated by roads and rivers and did not have many forests. This led us to consider geodesic distance as a reasonable proxy for traveling times in our models and also to treat the case of being located on the same river as one of our candidate explanatory variables for migration preferences.

We have distinguished three periods of analysis. Around 1825, there was no massive mobility towards cities. Around 1860, the urbanization process had started with massive outflows from the villages to the cities and industrializing towns. Around 1880, the intensity of migration was dramatic. It is one of the only cases in which (in 19th-century France) one could apply the traditional vision of "rural exodus." Our sample includes Lille (60,000 inhabitants in 1800, 200,000 in 1890) as well as two of the fastest-growing 19th-century French towns due to their manufacturing activity (especially in the wool industries): Roubaix (which grew from 9,000 to 115,000 inhabitants) and Tourcoing (from 11,000 to 65,000). The sample also includes many smaller towns and villages: 17 *communes* had less than 1,000 (but never less than 200) inhabitants in 1851 (Figure 3).

Our data allow us to describe some of the economic and social characteristics of the region, or at least of the people who married there during our three periods (for more details,

[7] It has been provided by the invaluable website "Des villages Cassini aux communes d'aujourd'hui", http://cassini.ehess.fr (accessed April 30th, 2010) that also presents the making of the map.

see the Appendix). Literacy among grooms increased from 49% to 60% to 81%; among brides it increased from 39% to 47% to 69%. The most common male occupations were day-laborers (12 to 20%—the word could describe all sorts of work in agriculture, industry, or services), cultivators (14 to 18%—the word giving no information on ownership), and weavers (9 to 16%; this could refer to an industrial or proto-industrial activity); the most common female occupations were cultivators (10 to 20%), day-laborers (13 to 18%), spinners during the first period only (10%; linen-spinning then was struck by a brutal crisis in the 1840s), and "without occupation" (11 to 17%). The figures for cultivators tended to decrease between periods, although this was not true in all *communes*. The high number of unspecified day-laborers, as well as domestic servants, maids, or farm servants (the addition of these occupations represented 20 to 31% of grooms and 24 to 29% of brides in each period), points to life-cycle occupations that were more generally common in Northern Europe. This will be discussed in Part 4 of this paper and might explain some of the features of migration that we observe.

A final peculiarity of this region that is interesting to us (and made us choose the West of Lille) is the linguistic boundary division. In the Western part, most of the inhabitants spoke Flemish in their daily lives, not French. However, this fact was not documented by official sources at that time; our linguistic map (Figure 4) is based on work by scholars who were generally regionalist activists. It is all the more interesting to test if we find patterns correlated with their reconstructions.

Figure 1 about here

Figure 2 about here

Figure 3 about here

Figure 4 about here

Data from marriage records

Our aim is to present a replicable research strategy. We therefore use archival material that should be reasonably easy to collect from many other places and periods. Since 19th-century France did not record migration *per se* in “population books"[8] (contrary to other countries such as Belgium or Sweden) we use an admittedly rough proxy, only counting as “migration” the differences between place of birth and place of dwelling at the time of marriage recorded by (civil) marriage certificates (to be legal, a marriage had to be recorded at the mayor's office). The median age of marriage in our sample was 29 for grooms (interquartile range: 25-34) and 26 for brides (22-31). We did not exclude marriages that were not the first for one or both of the spouses—they nevertheless represent a small proportion of our sample.

On the one hand, this leaves aside several types of migration: migration after marriage, by non-married persons (who might have been generally more mobile), and first migration(s) followed by others or by a return migration before marriage. On the other hand, this includes both young people who migrated alone and children accompanying their parents. As many migrations occurred during the first decades of life (this pattern was already identified by Ravenstein, 1885), it is not an unreasonable proxy for migration and certainly one of the most accessible. Quantitatively, it captures a significant part of mobility. Qualitatively, it probably underestimates “vagrant” mobility by the poor: they were the most sensitive to economic short-term conjunctures, and they had more difficulty obtaining marriage licenses. One can nevertheless make the assumption that this selection’s effect is weaker in our sample than in most French regions where land ownership or long term farming leases were the dominant model. Northern France was characterized by the early diffusion of the wage-earning model,

[8] As opposed to many European countries, France does not have population registers tracing the trajectories of moving households – except, for the 19th century, in a few places that, apart from Versailles, were located on the Belgian or German border (Pinol, 1996, Levy-Vroelant, 1988, Héran, 2004). Military registers offer this sort of information, but they focus on young male adults (20 to 45 years old).

within both the industrial and agricultural sectors. Finally, focusing on marriage certificates, i.e., "settlement" migration rather than "short-term" migration, allows us to see not merely the impact of *any* circulating information about the job market, but a *mixture* that combines the job market and marriage market, which is quite congruent to the issues that we raise. We will discuss the role of the marriage market in our migration field in the concluding section of this paper.

Our proxy thus includes people who moved to take one of their first jobs and/or to marry —the choice of the place, in both cases, likely to have been influenced by information obtained from social networks (including previous migrants) as well as by other factors, such as distance and other forms of proximity inducing social contacts (e.g. being located on the same river, in the same larger administrative unit, etc.). Marriage records, in addition to the places of birth and residence of the spouses, also indicate their date of birth, occupation, signature, or lack thereof (a rough indicator of literacy) as well as the same data regarding their parents (when they were alive) and (generally four) witnesses. We do not use the given information on parents and witnesses in this paper, but they could provide useful complementary elements.

In each *commune*, ca. 70 marriage records were entered in our dataset for each period with a time-span that varied according to the size of the village, town or city. This seemingly odd sampling scheme[9] allowed us to gather data on the patterns of migration between all possible pairs of places, including the small villages. Our database comprises 15,437 marriage records (ca. 70 records x 75 *communes* x 3 periods), each including information on two "migrations" (bride and groom, with very few missing data), so that we ultimately observe ca. 10,000 different "migration trajectories" per period.

[9] In retrospect, it would probably have been better to choose the same time-span for each place, using a random sampling in the towns and cities. We however had to adapt to practical constraints on data-collection.

We naturally weighted the data afterwards in order to adjust for the over-sampling of small places. For example, in Séquedin (ca. 600 inhabitants), we had to include all records from 1877 to 1887 in order to gather 71 records; on the contrary, five months in 1880 were sufficient for the town of Armentières. Accordingly, we weighted single records as a function of the time-span and the exact number of records entered in each place. For example, in this third period, the time-span necessary to gather 70 records in Séquedin was about 25 times longer than in Armentières. We thus weighted the trajectory of each groom in Séquedin as representing 0.09 in terms of migration, while that of one groom in Armentières weighted 2.4 in. What we obtain by aggregating trajectories between the same pairs of places is therefore not "actual" observed numbers of migrations; however, our figures can be expected to be proportional to the total number of moves made by new spouses marrying around 1879 from their place of birth to their place of dwelling[10]. All the figures given in this paper regarding observed migration, literacy, and occupations result from an aggregation of the weighted data.

Hypotheses

Our hypotheses are drawn from previous studies of migration and from what we know about the region being studied. We consider that the number of observed migrations between each couple of places could be influenced by three sets of factors: first, distance and population (as in the gravitational model); second, phenomena of hierarchy or homophily between places, i.e. preferences related to other characteristics of the *communes* or similarities between two *communes*—this includes aspects of urbanization and industrialization as well

[10] 1825, 1860 and 1880 were our original starting dates, but 1826, 1860 and 1879 are closer to the median dates of marriages actually entered by our research team.

as, for example, linguistic boundaries; third, previous migrations and structural factors related to social contacts with previous migrants (as in Hägerstrand's research).

As for the first set of hypotheses, it is not unreasonable to suspect that, other things being equal, migration was more common between *communes* that were close to each other and that had many inhabitants. This is summed up by the “gravitational model” which states that the total number of migrations between two places (the direction of migration is not considered here) is equal to a coefficient A, multiplied by the populations of the two places, and divided by the distance between them elevated to the power B (as an undue, but now classical extension of the gravitational metaphor, which presupposes the power 2). It is quite easy to use a linear regression on the logarithms of the observed figures in order to estimate these coefficients (e.g., Taylor, 1975). The R^2 of the gravitational model lies between 0.23 and 0.26 for our three periods, indicating some adjustment, but also a fair amount of dispersion, so that it seems reasonable to control this distance and population as well as to have a closer look at residuals. Part 3 of this paper therefore briefly discusses the total numbers of observed migration and the coefficients of the gravitational model, while Parts 4 and 5 only study the residuals of the gravitational model, considering them to be a matrix of over- and under-attractions between places[11].

We have thus considered that there was an “over-attraction” from *commune* A to *commune* B if the observed number of migrants was above the number predicted by our gravitational model for the period. This was classified as a directed tie in our network; the opposite case

[11] We have chosen this strategy because if we had directly processed the observed data, some of our findings could have been suspected to simply reflect effects of population and distance. It should however be noted that what we consider as “effects of population and distance” are in fact proxies for other social mechanisms, some of which might be quite similar to those that we study below.

("under-attraction") was classified as an absence of tie[12]. This produced matrices with densities of 9-10% in each period, meaning that each *commune*, on average, had seven different "over-attraction" ties with others in the sample—the actual number of preferential places for in-migration or out-migration ranging from 0-19 for each different *commune* period and direction of migration.

Our second set of hypotheses concerns the effects of various attributes of the *communes*. Some might attract in-migrants from more various origins; others might send out-migrants to more various destinations. This first subset of effects, which might be deemed "hierarchical", is related to the general notions of urbanization and industrialization and thus can be expected to explain some of the changes in migration fields between periods. A second subset of effects can be deemed "homophilic": it captures various ways to move between close, similar or familiar places—apart from simply moving to close places in terms of geodesic distance, which has already been included in the gravitational model. One of our main purposes is to assess the relative weight of each subset of effects.

[12] This dichotomizing might create undesirable effects, e.g. "changes" in the network due to minor variations around the threshold. Joscha Legewie suggested us a strategy based on simulation to deal with this issue, but we have not yet been able to implement it. We have however tried to use a different threshold, only considering as "over-attractions" the fluxes representing at least 1.5 times more migrations than expected. The triadic censuses (presented here in part 4) give extremely similar results (with the same hierarchy of over-representation of triad types). In the blockmodeling, the optimal number of blocks is slightly different (4 rather than 3 in the first period, 4 rather than 5 in the second and third periods), but the resulting blocks generally are a simple combination of the blocks obtained with a threshold of 1. The blocking is more different from the one described here for the first period, but its main pattern (the opposition between linguistic zones) is the same. The "light-grey-triangles" block of French-speaking *communes* that appears in Figures 12 to 14 below is not individualized with a threshold of 1.5: it is classified with the "grey" or "unclassified here" more Western *communes*.

Among "hierarchical" effects, we expect to find over-attractions to Lille, Roubaix and/or Tourcoing, and perhaps more generally to the largest and/or most industrial *communes.* It must be noticed that a large indegree in our network represents a wide, diverse migration field, which is not necessarily a high number of total "real" migrations. The most important cities are nevertheless likely to have had such a wide field. We expect this effect to become more and more important in the second and third periods. We could also hypothesize a more general effect of attraction from less-populated to more-populated *communes*, and/or from "poorer" to "wealthier" *communes*, as indicated by the average taxes paid.

In addition, we used data on the presence of industries and of some public infrastructures in the *communes* in order to test an approach in terms of opportunities, if not directly intervening opportunities (Stouffer's model being quite difficult to test empirically). Another version of the rural migration argument would state that places offering these jobs or services had a wider in-migration field than others. A final, alternative measure of this general idea of local opportunities is provided by the literacy and occupational data of spouses: we could, e.g., hypothesize that places characterized by a high literacy rate or some attractive occupations would have a wider in-migration field.

We used the following attributes of *communes* to test for such possible "hierarchical" effects:

- a dummy for only Lille, or for Lille, Roubaix, and Tourcoing;
- population from the official censuses in four periods (1806; average of 1826 and 1831; average of 1861 and 1866; average of 1876 and 1881);
- taxes paid per inhabitant at the beginning of the century (from *Statistique*, 1804);
- indicators of industrial activity in the 1860s. They are extracted from the *Joanne*, 1869, the main travel guide in France. This kind of publication did not only document touristic but also socio-economic information. It recorded plants, mills, and the main

textile activities in a qualitative and probably not very consistent way. We created dummies for the presence of a textile industry, agro-industry, and chemistry or pottery, as well as an index based on the addition of the three dummies;

- the fact of being the *chef-lieu de canton* (center town of this wider administrative unit where e.g., gendarmes and justices of the peace had their offices);

- an index of public services at the beginning of the century (from *Statistique*, 1804; based on churches, markets, first-degree courts, etc.) and in the 1860s (from Joanne, 1869; based on markets, notaries, post offices, customs, tax offices, charity services);

- an index of social services in the 1860s (from Joanne, 1869; based on municipal charity offices, mutual help societies and hospices);

- occupational data that deserves a longer comment (see Appendix). Suffice it to say that we classified the *communes* in clusters according to the literacy and main occupations of spouses—and that the results appeared much more complicated than expected, far from our initial assumptions to distinguish between a rural, agricultural Flemish-speaking West and a more urban, textile, French-speaking East;

- data on postal flows (letters, newspapers, printed material, etc. sent and received per inhabitant) from *Relevé*, 1847[13]. We used the volume of these flows and some composite indicators (e.g., part of local flows in the total traffic) as proxies of cultural activity or local *vs*. national integration—which are considered as possible characteristics of more or less attractive places in terms of migration.

Apart from such effects, we also expect to find more "homophilic" logics at work in the matrix of over-attractions. It could make sense to migrate to relatively "close", "similar" or "familiar" places, be it to find a spouse or a job. What we want to show here is the variety of meanings that proximity or similarity could have, which points to alternative strategies

[13] The source and the variables that it records are described in Dauphin, Lebrun-Pezerat, and Poublan, 1991 and http://crh.ehess.fr/docannexe.php?id=1155 (accessed April 30th, 2010).

available even for those who could not or did not want to move to a "bigger" place (in terms of population, economic activity or administrative weight). Moving to a similar place could make sense because it was likely to offer job opportunities (if the place was similar in terms of industries or occupations) and/or because better information was available due to previously existing social networks based on physical proximity, a common language, or opportunities to meet (e.g., in markets or local courts).

We used the following attributes of *communes* to test for such possible "homophilic" effects:

- indicators of industrial activity in the 1860s (see above);
- occupational data (see above);
- location on one of the main rivers: Borre, Deule, Lys, Marcq. They may have mattered either as transportation or, in all probability, as one of the key industrial raw materials and sources of energy for textile industry, therefore creating small, fairly homogeneous industrial valleys;
- adjacency (the fact that two *communes* shared a common border): even if distance has already be taken into account by the gravitational model, this specific form of proximity could have additional effects, e.g., for hamlets located at the border between two *communes*. It is also a proxy for the absence of "intervening opportunities" in Stoufferian terms;
- main spoken language;
- belonging to two sorts of administrative districts: *canton* (a small unit) and *arrondissement* (a larger one). The former often included 5 to 10 villages in rural areas, the latter a few dozens. These districts were used, e.g., to define voting areas, the jurisdiction of local courts and the police or gendarmes; markets and fairs were also organized in their center towns for the *communes* of the district.

Finally, our third set of hypotheses is based on a different definition of the notion of "close" or "familiar" places. In addition to adjacency, similarity of language, occupation, etc., we want to test the idea that migrations create channels influencing future migrations through mechanisms based on personal relationships between migrants and their former and new neighbors. In terms of network analysis, this can be tested, on the one hand, by looking for specific forms of dyads or triads (migration preferences inside couples or groups of three places) in a given period, which only gives indirect hints of the underlying social mechanisms. On the other hand, as our data cover three different time-periods, we can model change in such "local" patterns ("local" in terms of network analysis, not necessarily of physical distance), which allows us to more directly test these hypotheses on the influence of previous migrations on those in the future. One of the originalities of our research strategy is thus to interpret some classical structural network effects (presented, e.g., in de Nooy, Mrvar, and Batagelj, 2005 and Snijders, Steglich, and van de Bont, 2010) in terms of relational mechanisms at work in migration, and to test them along with more classical, "hierarchical" or "homophilic" effects. What will we consider to be mechanisms of these types of effects?

A tendency to find *reciprocity* in "over-attractions", and even more to find attractions that become reciprocal between periods (when more people than expected migrate from A to B in period i, more people than expected also tend to migrate from B to A in period i+1) might indicate effects of economic complementarity (if each of both flows implied a different sort of workforce); it is also quite likely to be related to personal contacts provided by earlier migrants, either discussing their place of origin with their new neighbors[14] or their place of destination with their former ones, and thus providing instrumental information for future moves.

[14] The word "neighbors" is used here in the loose sense of people living in the same *commune* and interacting with the migrant. They could be kin, colleagues, or have any other sort of relationship with the migrant.

A more extended version of this argument could lead to high *transitivity* rates, and especially to non-transitive migration flows becoming transitive in the next period. This "transitivization" can be defined as follows: when more people than expected migrate from A to B and from B to C, more people than expected also tend to migrate directly from A to C in the next period. This could be caused by information flows similar to those discussed for reciprocity: migrants discussing with their former neighbors induce information flows from C to B about opportunities in C, and from B to A about opportunities in B, but also possibly about opportunities in C. Discussions happening in B between people connected to migrants in C and former migrants from A would allow information to move further backwards through indirect personal contacts.

However, the software that we used to model network dynamics includes two slightly different types of changes under the indicator of "transitivization" used in our model[15]:

- when more people than expected migrate from A to C and from B to C, more people than expected tend also to migrate directly from A to B and/or from B to A in the next period. This process is slightly different, but could be explained by the same phenomenon of information moving backwards to former neighbors (from C to A and from C to B), general discussions happening in the most central town (C in this case), and helping information to circulate through indirect relationships. In this case, it would lead people in A to be informed on opportunities in B, and vice versa. Another mechanism may be specific to kin networks. For example, a male migrant from A to C marrying a female migrant from B to C would create opportunities for both lineages to meet and circulate directly between A and B;

[15] We could have chosen another indicator ("number of actors at distance 2", instead of "transitive triplets") provided in the same software, that concentrates on the first type of transitivity (Snijders, *et al.*, 2009). We have nevertheless considered that the three mechanisms involved were close enough to be tested as one, as our main purpose was to assess the weight of structural effects generally, as compared to hierarchical or homophilic effects.

- when more people than expected migrate from A to B and from A to C, more people than expected also tend to migrate directly from B to C and/or from C to B in the next period. What is at play here is the information discussed by migrants with both their new (migrants being able to, e.g., bring in B not only their direct information about A, but also indirect information about C that they found in A) and former neighbors (information from B and C becoming available in A). This would make sense, for example, in the case of kin networks (e.g., of siblings born in A and migrating to B and C).

While the precise mechanisms at play in each case are slightly different, transitivization thus always appears as an effect of the addition of information conveyed backwards by previous migrants and general communication happening in the *commune* and having the highest degree. Finding significantly high—or low—rates of transitivity, all things being equal, would thus give us an answer to the importance of social contacts created by former migrants for the circulation of information flows about migration opportunities.

The case of what is called *3-cycles* in network terms provides another variant of possible relationships between three places. A significantly positive coefficient of 3-cycles in the dynamic model would imply that when more people than expected migrate from A to B and from B to C, more people than expected tend also to migrate directly from C to A in the next period. If we think of this pattern in terms of information circulation, we could conclude that information, instead of flowing from destination to origin (as has been hypothesized in most of the cases of transitivity) flew from origin to destination. The inhabitants of C would thus be directly informed about B and indirectly about A by incoming migrants (and their relatives), which would lead some of them to migrate to A. Comparing coefficients found for transitivity and for 3-cycles should therefore help us to differentiate between the significance of personal relationships of migrants with their new and former neighbors.

Finally, a different mechanism could lead transitivity indicators to be significantly low. It would happen if the establishment of a direct migration from A to C destroyed previously established preferences from A to B and from B to C—e.g., in the case of a step-by-step migration from village to city through a middle-size town that would only result in more direct migrations. Step-by-step migration in itself—either the same individuals or different sorts of workforce coming from the country to intermediary towns and from those to big cities (Hägerstrand, 1957)—is more difficult to trace in our network. However, a high *betweenness* indicator in the dynamic modeling would point to the fact that some places increasingly play the role of hubs for migration, receiving migrants from and sending migrants to various otherwise unconnected places.

Structural concepts generally used in social network analysis therefore help us to specify several different mechanisms that might be at play under the general notion of "the importance of personal relationships for migration fields." Hägerstrand and his followers often seemed to contemplate several of these mechanisms at the same time. Our case study will help us to disentangle them in order to understand what was happening in 19th-century France—as comparative research would be needed to assess if some of these mechanisms are typical of all sorts of migration, or if they are more specific for a period, place or scale of migration or for precise types of migrants.

3. A macro view of migration in our region

Before coming to the results of our network analysis, we present here the main characteristics of migration in our region in terms of broad social categories and the influence of distance and population (the "gravitational model"). They generally confirm what was already known about migration in 19th-century Europe—which leaves important questions unanswered that we will address in Parts 4 to 6 of this paper.

Socially differentiated migrations

Our research strategy is based on the analysis of a complete network. Most of our results therefore concern migration between the *communes* of our sample: what we want to understand is the structure and evolution of this migration field. We nevertheless have to mention other types of migration that are present in the data. In our weighted observations of places of birth and residence, we found 42% of sedentary spouses (40% of grooms, 44% of brides), 28% of spouses born outside of our field of observation (31% of grooms) and less than 0.5% of spouses living outside of the sample (although they had married there). In the first period studied, sedentarity was a bit higher (46%) and in-migration a bit lower (21%) than afterwards (40% and 29%)—but these changes do not appear drastic in a region that experienced such a fast industrialization and urbanization process. To give a comparison from data also based on marriage records according to Rosental, 1999, the global sedentarity rate for 19th-century France was 53%. As said earlier, we are thus observing an area that was more mobile than the rest of the country.

Our investigation finally concentrates on only 29% of the trajectories that we could reconstruct. It is of course important to keep these numbers in mind: our region was by no means an "actually" closed network of places. Some of the *communes* that do not seem to have many ties within the sample probably had their own migration fields elsewhere; defining boundaries for a network study is always difficult (Laumann *et al.*, 1992); however, our purpose is not the same as in most network analyses; For instance, our aim is not to show which *commune* is the most central in the sample (which would be heavily influenced by boundary issues). Our research is quite centered on dyadic and triadic patterns that may be expected to be less sensitive to these problems. In addition, the data shows that few in-migrants happened to come from neighboring French *communes*; a majority was actually born in Belgium. This peculiar migration has been studied in 1996 by Rosental who showed that in the 1820s, it happened mostly on a short-distance scale (from places close to the border) and strictly respected the linguistic boundary. Distances then increased, but the linguistic boundary remained heavily influential to migration until the 1870s when all flows turned to the industrial region immediately around Lille, Roubaix, and Tourcoing—this violation of the linguistic boundary possibly being one of the causes of the xenophobic reaction against Belgian migrants. Even if we cannot directly integrate the Belgian migration into our network study, we can look for different or similar patterns in our region in regard to the influence of distance and language.

Aggregate figures on observed migration inside our sample allow for a preliminary test of the weight of the linguistic boundary. If we begin with a rough distinction between French-speaking, Flemish-speaking *communes* as well as the mixed cases (as defined in Figure 4), and if we single out movements towards Lille, the weighed observations can be divided: 58% between French-speaking places other than Lille, 26% from any place towards Lille (29% for women), 8% involving mixed cases, 5% between Flemish-speaking places, 1.8% from a Flemish-speaking to a French-speaking place other than Lille, and 0.3% in the opposite direction. These figures are quite stable over time, except for an increase of the first type of movements (51% in the first period, 63% in the third) at the expense of intra-Flemish migrations and movements towards Lille.

This raw statistical data seems to assess the weight of the linguistic boundary. Additionally, in absolute terms, mobility was higher in the East than in the West, which may just be a consequence of the fact that Flemish-speaking *communes* were less populated on average. This points to the necessity to first apply the gravitational model and then look for structure in the residual if we want to get a better view of migration. However, what we can do with the original figures is look for specific patterns of migration among some categories of individuals, as defined by a combination between period, gender, literacy and occupation.

We have isolated the 95 most frequent combinations of this type in weighed data (e.g., "male literate butchers, third period") and computed the frequency of each type of migration (general or inside the sample) among them.

Results of sedentarity and in-migration confirm well-known conclusions of migration studies: 4 out of the 6 most sedentary combinations (more than 75% of sedentarity) comprise female cultivators, and 7 out of the 14 most sedentary combinations include the occupation "cultivator"[16]; 6 of the 12 least sedentary profiles (less than 20% of sedentarity) are those of servants or female cooks. These occupations, along with housewives, largely overlap with the category of spouses born outside of the sample. By contrast, female cultivators were almost never born outside of the sample (but male cultivators were only a bit below the mean in this respect).

Movements between French-speaking places clearly over-represented weavers and some other textile occupations—meaning that either weavers made this sort of move or this sort of move was made in order to become a weaver—while it was overwhelmingly servants (especially farm servants and illiterate spouses), who migrated between Flemish-speaking *communes*. This is both an outcome of two different regional occupational structures (see Appendix), and of patterns of economic and life-cycle migration. People who migrated to Lille (from French- or Flemish-speaking places) were generally neither spinners nor cultivators; employees (in retailing or railways) and seamstresses were over-represented among them, as were literate spouses. This is undeniably an outcome of Lille's administrative position as the capital city of the region. Finally, only a handful of migrants with no obvious attributes in common crossed the linguistic border, so it is difficult to draw any conclusion from them. The dominant feature is still the limited amount of mobility over the "linguistic" boundary.

[16] Such results must be interpreted with caution, as we only observe occupation at the destination place. If a day-laborer moved and became a cook, we will only know him or her as a cook.

In a region with an admittedly complex socio-economic structure, it is not easy to find individual attributes that clearly determine migration patterns, apart from those that are hardly surprising: cultivators were more sedentary, servants moved within the Flemish-speaking zone, and clerks and literate spouses moved to Lille. If aggregate individual attributes do not explain much in terms of aggregate migratory patterns, it is all the more interesting to turn to the structure of our migratory field.

Distance, population and migration: the gravitational model

As already mentioned, we have used linear regression to determine coefficients in the classical "gravitational model" of migration, which gave an R^2 of 0.23 to 0.27 in each period —a reasonable, but not excellent adjustment. More interestingly, the coefficients A (multiplying population) and B (the power that distance is elevated to) did not vary much either; A fluctuated between 14.3 (first period) and 14.8 (third) and B between 1.06 (second period) and 1.17 (first). If there was a tendency of an increasingly more important effect of population, it was limited at best and not much seems to have changed regarding the effect of distance, which is a surprise. The available means of transportation arguably did not evolve much within our small region; however, we could reasonably have expected urbanization and industrialization to prompt long-distance migration, mobility towards the largest centers, and/or greater access to general information on opportunities to migrate (e.g., in newspapers), thus reducing the impact of personal relationships on migration. This would have affected coefficients A and B—however, that is not the case: at a macro level, we once again find stability in migration over the 19^{th} century.

4. Local and global patterns of over-attraction

The coefficients obtained for the gravitational model allowed us to derive a matrix of residuals from the observed data. We consider these residuals to be over-attractions when the observed migration exceeds the expected migration (according to the gravitational model), while the reversed cases are considered to be under-attractions, treating the data as a binary, oriented network. Our hypotheses (Part 2) lead us to use multivariate modeling, especially actor-oriented network modeling (Part 5). However, preliminary analyses are needed, for two different reasons. On the one hand, studies based on "local" (dyadic or triadic) patterns in networks often postulate their aggregate consequences more than they actually study them. It is interesting to know, for example, that there are many symmetrical over-attractions in our sample, yet it is even more interesting to know where they happened (on short or long distances, in which sub-regions, etc.). In this respect, like a few other scholars before us (Lazega, 2007; Lazega, Sapulete, and Mounier, 2009), we chose to use blockmodeling as a complementary research strategy allowing us to identify patterns on the scale of the whole region; maps were also used in order to locate some of the significant "local" patterns. On the other hand, we have many candidate explanatory variables for hierarchical and homophilic effects. A separate, more descriptive analysis of interactions between each of these variables and the migration field allows us to select those that deserve to be tested in a multivariate model.

Local network patterns

Triadic censuses provide a first idea of the micro-structures within our network, at the dyadic and triadic scales[17]. By not taking attributes of the *communes* into account, they do not allow for the simultaneous test of all our hypotheses; they do, however, provide a first rough view of the structural mechanisms that could be at play. Figure 5 defines all the possible types of triads, while Table 1 compares the observed and expected frequencies of each type in our network of over-attractions.

Figure 5 about here

Table 1 about here

The over- or under-representation of each sort of triad did not significantly change from one period to the next. Once again, from this point of view, the general migration patterns within our region appear stable.

The network of over-attractions is generally not very dense, as there were a large number of null migrations; but the densest, cliquish-looking local patterns (types 11-16) are clearly over-represented. Along with type 3, these are the triads that involve forms of reciprocity, which thus appears to be an important phenomenon in our data. On the contrary, clearly hierarchical types (4 and 5) are under-represented; type 13, however, could also be viewed as hierarchical and it is quite frequent. Reciprocity is definitely the dominant pattern, whereas the tendency to an over-representation of "egalitarian" patterns (that could be derived from a "micro-mobility", random-like vision of intra-rural migration) is not always present. For example, 3-cycles of generalized exchange without reciprocation (type 10) are under-

[17] We used the routine implemented in Pajek (Batagelj and Mrvar, 1998), that allows comparisons with a random structure. Interestingly, the patterns that we found do not fit in the classical models devised to interpret triadic censuses in the case of interpersonal relationships ("balance", "ranked clusters", etc.) (de Nooy *et al.*, 2005, 204-225). Studies following our approach of migration could help to conceive more appropriate interpretations of triadic censuses in the case of flow matrices.

represented, while the quite similar type 14 is quite over-represented. "Pure" transitivity (type 9) is not more frequent than in random networks, yet transitivity with partial reciprocation (type 13) is more frequent. Apart from this tendency towards reciprocity and even towards the formation of complete cliques (type 16)[18], these static patterns thus do not signifantly help us draw conclusions about our structural hypotheses.

Notwithstanding these limits, the analysis of triadic patterns already adds considerably to our aggregate view of migration, provided that we project the results on maps[19]. To start with, they offer a more precise account of the differences between the two linguistic regions of our study area.

Figures 6 to 11 about here

Out of a total of 500 to 530 over-attractions in each period, there were 80 to 100 reciprocal ties, thus representing one third of the over-attractions—slightly more in the second period than before or after. Figures 6 to 11 show that this tendency of reciprocation, as well as clique formation (as approximated by triads of types 15 and 16), was more typical of the Western, Flemish-speaking part of the sample. Reciprocation without densely overlapping cliques was found in the central part of the French-speaking region, but not in the more urban and industrial East. In addition, it was generally short-distance preferential ties that were reciprocated: the Pearson correlation between adjacency matrices and reciprocated over-attraction matrices is ca. 0.4 for each period[20]. This general reciprocation pattern points to a

[18] 15 highly overlapping 4- or 5-cliques are found in the second period, 6 in the third – but only one in the first.

[19] This is done simply by placing the cercles representing *communes* according to their geodesic coordinates, and adding the lines representing over-attractions of a peculiar type. In Figures 7, 9 and 11, the lines represent over-attractions that are included in at least one triad of type 15 or 16.

[20] As computed by QAP-correlation, a technique based on random permutations and implemented in Ucinet (Borgatti, Everett, and Freeman, 2002).

first, quite simple pattern of the Flemish-speaking zone: rural, local, non-directed migration perhaps complemented by more asymmetrical attractions to Lille, Roubaix, or Tourcoing. The situation seems different in the French-speaking zone in that symmetrical or clique-like over-attractions were less frequent. However, a separate triad census centered on over-attractions between French-speaking places shows that triads including reciprocation, and especially triads of type 15 and 16, were also over-represented when compared to a random network. It implies that, although there were less over-attractions in this area (the size of migration fluxes being that or less than that predicted by the gravitational model), those that existed followed the same patterns as in the Flemish-speaking zone.

To understand the significance of these preliminary findings, it is necessary to go back to the very core of our data. Marriage records capture information about young people who are settling down. The occupations that they declared to the town clerks are only hints of a complex process. In some cases, such as civil servants or craftsmen, the occupation was probably related to some sort of training (e.g., apprenticeship). This was, however, not true in most cases. Young men and women raised in industrial towns or cities may have entered workshops or factories at an early age, some getting specialized, for instance, in the textile industry, others becoming day-laborers. In Northern France, most of the young people raised in the countryside—including the ones who afterwards migrated to a town or city and declared themselves as, e.g., "workers" or "cooks" – followed the so-called "North-Western European life-cycle servants model" (Hajnal, 1982; Kussmaul, 1986). As teenagers, they experienced a long phase of intensive mobility between villages, partly driven by family or community networks. This pattern was generally shared by their peers, siblings, other relatives of the same generation, and friends who were closest in age. It made them acquainted with a few villages where they found jobs—often as farm servants or day-laborers —and spouses. Closely observing the migration fields of the handful of villages (all Flemish-speaking), where more than 5% of the grooms were farm servants in each of our periods, shows the clearest picture of an internal clique-like structure, while at the same time they sent many migrants to Lille in the second and third periods.

At this stage, our findings indicate the following: in the most rural part of our area of study, over-attractions were frequently reciprocated and part of dense overlapping cliques. Meanwhile, it was exposed to the growing attraction of towns, cities, and even the metropolis of Lille: a phenomenon that was already described at that time. What we are now able to consider is the feedback effects of urbanization within the countryside. What our data demonstrate—although the dynamics at this stage can only be hypothesized—is that the Flemish villages, as it were, maximized the use of resources available within the countryside by intensifying their relationships among themselves. Whether villagers did not want to leave to the big cities located a few dozen miles away, or whether they did not have the resources (money, networks, information) necessary to leave, they seem to have implemented a systematic exploration of opportunities provided by neighboring communities. This might explain why the coefficient of distance in the gravitational model did not decrease over time: even though the North of France experienced long-distance moves between villages and Lille, this process was accompanied by a densification of short-distance ties between Flemish villages, which has generally remained invisible because most of the available statistics were only concerned with the arrival of rural migrants in the cities.

While we need a multivariate model (Part 6) to more precisely test this hypothesis, Figures 6 to 11 already give an idea of how the process unfolds. A closer examination (including labels) would allow us to see that the Flemish-speaking or mixed-language small towns (Pradelles, Cassel, Bailleul, Hazebrouck) were either excluded from the cliquish-like structures of villages or only loosely integrated in them, which confirms our preliminary hypotheses. These maps also express what happened in the French-speaking zone. The *communes* of this zone that were included in reciprocal over-attractions and/or triads of types 15 or 16 were located in the central or southern parts of the sub-region. They were not small villages, as many populations exceeded 2,000, but were less urbanized and less industrialized than the northern and eastern parts of the French-speaking zone. Over time, the group of *communes* located in this zone became increasingly connected with each other and even started to develop indirect ties with the Flemish-speaking zone.

Mapping migration fields through blockmodeling

Blockmodeling techniques allow us to cluster actors involved in a network such as*communes*—according to shared patterns in their ties to other actors and the shape of their in- and out-migration fields. They are especially useful to detect either relatively closed clusters of actors having more internal than external ties (which could describe our densely overlapping cliques of villages) or center-periphery structures (which could account for the attraction of some towns or cities). Contrary to triad censuses or the model that we will discuss in Part 5, they are intended to provide a global image of the structure of the network. We use them here in order to verify the first results given in the previous section by once again representing the results of the blocking on a map. It is especially useful in order to get a more precise idea of changes in the global structure.

For blockmodeling, we used the software Blocks (Snijders and Nowicki, 2007), which has three distinct advantages: it provides indicators that help to choose an appropriate number of blocks; it points to cases that are difficult to cluster (we have chosen to exclude them from image matrices and to mark them as pluses on the graphs); and, most importantly in our case, it specifically takes into account the orientation of ties, thus providing separate image matrices for reciprocated and non-reciprocated ties. Figures 12 to 14 show our results: in each case, the graph is based on the geodesic coordinates of *communes*, thus giving a "map" of the network; it is accompanied by a synthetical "image matrix" and by the original matrix of over-attractions clustered according to blocks. In this matrix, grey squares indicate non-reciprocated over-attractions and black squares indicate those reciprocated[21].

In the first period, three groups were clearly distinct, geographically as well as in network terms. These sub-regions were quite loosely interconnected: even large cities in the East did not distort their features (apart from inducing a few migrations from the "dark-grey-triangles" to the black block). It is worth noticing, considering there was a clear boundary in attractions, that this period did not exactly follow the linguistic border depicted in Figure 4. This tends to confirm the moving and/or blurred nature of the border between the Flemish region and the central/southern part of the French-speaking area. In addition—and this is true for all three periods—the blocks defined by migration patterns are not significantly correlated with our socio-economic clusters (as defined in the Appendix): although there is a statistical tendency of homophily within these clusters, as we will see below, it is not strong enough to be the main causal factor of blocking. It is more likely that a combination of adjacency, *canton,* and language homophily determined the shape of these blocks.

In the second and third period, the structure was vaguely defined (in terms of blockmodeling, according to the indicators provided by Blocks) and more complex: cities and towns, and especially the influence of Lille, partially distorted the previous patterns. There was still a relatively cohesive and closed Flemish-speaking group whose attractions were reciprocated more often than during the first period—consistently with our previous hypothesis based on triadic censuses. This group was nevertheless getting smaller, and actually becoming restricted to the linguistic region depicted in Figure 4. We only have a static vision of which languages were spoken in each place during the 19th century. This evolution of the Flemish-speaking group might indicate that either more *communes* were

[21] The matrices were produced by Pajek (Batagelj and Mrvar, 1998).

actually Flemish-speaking in the first period than indicated in Figure 4, or (if the linguistic patterns changed slower than the migration patterns) there was a stronger preference for migration in the same linguistic zone during the second half of the century.

Lille, along with four or five middle-sized towns, was part of an intermediary block (dark gray triangles) receiving migrants from the two linguistic zones. In the second period, Roubaix and Tourcoing were still not very connected to the rest of the sample: migrants who arrived there came from other regions, especially from Belgium. On the contrary, they tended to play a role more similar to that of Lille in the last period, while still not becoming part of the "dark-gray-triangles" block. Finally, a relatively cohesive block of French-speaking *communes* (light gray triangles) appeared in the second period and maintained itself in the third. As far as we know, these *communes* did not have much in common in terms of size, activities or even *cantons* or rivers. As seen earlier, the main common features between these *communes* are the fact that they are French-speaking, increasingly escaping the immediate attraction of the three big metropolises from the East and adopting migratory patterns relatively similar to those of the Flemish-speaking sub-region. They would certainly deserve a more micro study.

Figures 12 to 14 about here

Attributes of places, homophily, and hierarchy

We have already mentioned correlations between triadic patterns, block positions, and attributes of the *communes*: mainly language, but also socio-economic clusters, for example. In order to assess the relative weight of the hierarchical and homophilic effects of these attributes and of "purely" structural phenomena related to personal relationships with former migrants (such as reciprocity or transitivity), we will use multivariate models in Part 5. The selection of variables tested in these models has been made due to preliminary univariate treatments attempting to correlate migration patterns with the available attributes. The general idea is to cluster the network according to these attributes and to investigate intra- and inter-cluster densities in order to find traces of homophily or hierarchy. We did this on account of a network auto-correlation[22] procedure for most attributes, as well as QAP-regression in the case of adjacency—both algorithms being based on random permutations and implemented in UCINET (Borgatti *et al.*, 2002). When the variables changed across periods (e.g., socio-economic clusters), we generally tested the influence of the clustering of period i-1 on over-attractions in period i. Since migrations mostly occurred during the interval between periods, they are likely to have been influenced by the past attributes of *communes*.

The outcome of these preliminary analyses is particularly interesting, as none of the various indicators of administrative or economic prominence happened to play any significant hierarchical role (i.e., to widen the in-migration field of the prominent *commune*). This was true for the status of *chef-lieu de canton* as well as for indexes of public and social services, industrial activity, data on postal traffic, and average taxes paid. There were only a few exceptions in this respect: first, there was a slight over-attraction to *communes* with chemical or pottery industries in the second period (as it did not appear significant in any multivariate model, it was probably correlated to more important effects); the second regarded migration between socio-economic clusters in the second period. *Communes* classified as “urban” in the first period tended to have a wider in-migration field in the second period, while *communes* classified as “proto-industrial” conversely had a wider out-migration field. This ressembles a rather classical view of rural out-migration, while defining it more precisely than standard models, and is probably related to a rather local event (namely the crisis that occurred in the linen industry in the 1840s).

[22] Network auto-correlation with categorical attributes, ANOVA density models, with the options “variable homophily” and/or “structural blockmodel”.

Another hierarchical structure was found (as expected) regarding attraction to the biggest cities. In this respect, the preliminary blockmodeling helped us define which exact preferences should be tested. In the univariate tests, there was a specific over-attraction from towns with more than 5,000 inhabitants to Lille in the first period, from all *communes* to Lille in the second, and from towns with more than 5,000 inhabitants to Lille, Roubaix and Tourcoing in the third. In addition, Flemish-speaking towns were initially attracted to Lille, moving on to Roubaix and Tourcoing in the second and third periods.

Accordingly, very few of the classical parameters used to understand the hierarchy of mobility flows and their orientation towards “attractive” areas (in terms of economic opportunities and/or collective services) appear to have played an important role; many more “homophily effects” seem to have been influential. Our univariate treatment produces various types of combinations:

- a “language effect” between the French, Flemish, and mixed *communes*;
- a “river effect” between *communes* located on the Borre, the Lys (in all periods), and the Deule (in the first period);
- an “administrative effect” between *communes* belonging to the same *arrondissement* or to the same *canton*[23];
- a “labor market effect” between *communes* belonging to the same socio-economic cluster[24].

In addition, the coefficient of the QAP-regression of migration on adjacency is highly significant for all three periods.

[23] Two *cantons* (Vieux-Berquin and Hazebrouck) showed particularly high internal densities for each of the three periods; among the ten *cantons* including at least four *communes* of our sample that were tested for homophily, six had significant rates for all periods and the remaining three for all but the second period.

[24] Except for migration in the third period between *communes* that had been classified as “day-laborers, urban” in the second period, homophily was found in all clusters. As we had no data to create a clustering before the first period, the clusters of this period were compared to migrations in the same period.

Of course, many of these indicators are in fact correlated. For example, it is likely that two adjacent, French-speaking *communes* had a similar socio-economic profile, were situated in the same *arrondissement,* and perhaps on the same river or in the same *canton*. Language and *arrondissement* are particularly correlated, but the language homophily correlation was quite stronger, leading us to exclude *arrondissement* homophily in our multivariate models. On the contrary, we tested *canton* and river effects that defined smaller and occasional overlapping areas.

This leaves us with a large number of non-structural effects to test in our further analyses. It is already worth noticing that, apart from the pattern of attraction to the biggest cities, these effects do not seem to significantly change between periods (although some of the attributes do).

5. Modeling change in migration fields

Most of our preliminary results lead to stable patterns of migration, both at a macro scale (like the coefficients of the gravitational model) and at a micro scale (like the triad censuses). However, the maps of specific local patterns, the blockmodeling, and some of the hierarchical effects already exhibited a certain amount of change that we tentatively interpreted not only as a correlation with urbanization, but also as a result of a feedback effect on intra-rural migration. We now proceed to a more direct discussion of dynamics. Whereas the multivariate modeling of the static structure of networks—as allowed by exponential random graph (ERG) modeling—is generally considered to be less robust than dynamic modeling, we will first give the results of such models for each period, as they will provide important references for some of the comparisons discussed in Part 6.

Comparative statics

A less direct but useful complement to triad censuses, exponential random graph (ERG) models allow for an analysis of the relative weight of structural network tendencies (e.g., reciprocity or closure) and independent attribute effects (e.g., attraction to Lille) for each period. In our case, both structural and independent effects played a significant role. The best models, with a very good convergence, are described in Table 2. We have chosen to test some of the generic "alternating" structural parameters, as they seem to be statistically more robust than those previously used (Snijders *et al.*, 2006; Robins *et al*., 2007). However, their interpretation is still somewhat experimental due to the scarcity of empirical studies having used them.

Table 2 about here

Some of the candidate effects (e.g., river effects not presented in Table 2, attraction to *communes* with a chemical industry, or general attraction to Lille in the second period) were not significant in any multivariate model. However, several hierarchical and homophilic effects were significant, even when confronted with more structural tendencies.

As for the latter—and surprisingly if the triad censuses is considered—reciprocity was barely significant; it may have been absorbed by stronger attractions between adjacent *communes* or by some of the homophilic effects[25]. However, the positive estimate for alternating k-triangles, along with the significant negative effect for alternating independent two-paths, confirm the outcome of the triadic censuses. The purpose or the alternating k-triangle effect is to model transitivity and clustering; along with a negative alternating independent two-path effect, it describes a segmented network consisting of multiple dense

[25] We tested the interaction between reciprocity and adjacency, but the estimate was negative.

regions connected by low density paths. This confirms that the clique-like phenomena so prevalent in our region could have "purely" structural causes—i.e., be related to personal relationships with past migrants—rather than occurring as a simple, indirect consequence of homophily.

The estimate for alternating out-k-stars, which becomes higher in the last periods, points to an important and growing variance in the size of out-migration fields (whereas it is not true for in-migration). It may be connected to the fact that Flemish-speaking villages both established new ties to the big cities and intensified their local ties, which was less true for most of the French-speaking *communes*.

The weight of the adjacency parameter exposes the importance of the most local connections *per se*, even when the adjacent *communes* were otherwise not similar. We are thus able to distinguish a general intuition on migration between "close" or "similar" places among several variants and to assess that these separate effects all played a distinct role. Over-attraction occurred more often between *communes* that were either adjacent to one another, shared the same language, developed the same socio-economic features (in the first and third period), belonged to the same *canton* or were located in the Deule valley (both in the first period). In addition, *communes* that shared common over-attractions probably tended to exchange more migrants than expected (as indicated by the transitive/clique-like effect described by the structural parameters). There were thus several ways to move to a "close" place; each which seems to have shaped individual agency, being mobilized by villagers who did not want or were not able to move to industrial towns and cities in the East. Whether they actually were able to choose a variant or were constrained from doing so due to certain particularities (e.g., their gender, literacy, or occupation) remains open to further micro investigation.

Dynamic modeling

The ERG modeling results still exhibit a remarkable stability. A lower homophily—at least for some variants—and a growing attraction of Flemish-speaking migrants to Lille, Roubaix, and Tourcoing (after the first period) appear to be almost the only exceptions to this pattern. However, if we closely consider the ego-centered migration field for each *commune*, the picture changes tremendously. Whereas there were 491 to 532 over-attractions in the network during each period with a quasi stable density, 305 new over-attractions appeared between the first and second periods: 265 disappeared and only 226 remained stable. The respective figures for changes and stability between the second and third period were 290, 289, and 242[26].

This implies that the sort of stable migration fields at a micro scale that Hägerstrand and his followers found in Scandinavia were not really common in our region—for reasons that remain to be investigated. The fact that such frequent micro-changes gave birth to a more or less stable regional structure is nevertheless quite interesting and in line with other findings by Hägerstrand, who was actually interested in innovation-spreading, not in immovable structures. The result is similar to what Lazega, Lemercier, and Mounier, 2006, termed a "spinning-top model": multiple micro moves or changes at the individual level are the conditions for a general structure to maintain itself—and, like Lazega *et al.,* 2009, this conclusion can be verified by adding that some global patterns, as captured by the blockmodels, were in fact also transformed. Snijders *et al.*, 2010, in a particularly accurate discussion of what we could call path-dependency in networks, similarly noticed that:

[26] This is just the acceptable amount of change for Siena modeling, as measured by the Jaccard index (2.9 and 3.0): our periods are not too further apart from each other to make dynamic modeling artificial, according to Snijders *et al.*, 2010.

> "If one has observed a longitudinal network data set of which the consecutive cross-sections have similar descriptive properties—no discernible trends or important fluctuations in average degree, in proportion of reciprocated ties, in proportion of transitive closure among all two-paths, etc., then it would be a mistake to infer that the development is not subject to structural network tendencies just because the descriptive network indices are stationary. For example, if the network shows a persisting high extent of transitive closure, in a process which is dynamic in the sense that quite some ties are dissolved while other new ties appear, then it must be concluded that the dynamics of the network contains an aspect which sustains the observed extent of transitive closure against the random influences which, without this aspect, would make the transitive closure tend to attenuate and eventually to disappear. […] Given a sequence of consecutively observed networks, if one were to make an analysis of the first one by an ERGM [odel] and of the further development by an actor-based model, then in theory it is possible to obtain opposite results for these two analyses, and this would point toward a non-equilibrium situation."

It is exactly what is observed here: this notion of non-equilibrium compatible with seemingly stable indicators offers new avenues to migration studies.

In order to begin to explore them, dynamic actor-oriented modeling was used as implemented in Siena (Snijders *et al.*, 2009). As explained in Part 2, this method offered parameters that fit exactly with our questions on patterns of future migration "contained" in those of past migration. As their name indicates, dynamic actor-oriented models have been developed to deal with individuals making (constrained) choices about their ties with other individuals, while taking into account information on the local structure of the network around them and on attributes of their potential partners. Does it make any sense to use such a model to describe over-attractions between places? We considered that it was not preposterous—not only for practical reasons (the statistical operations performed by the software computed what we wanted them to compute), but also because our vision of migration is not at odds with this model. Of course, "places" did not decide on their ties, nor did the inhabitants formally gather to deliberate on migration. But our hypotheses are based on the idea that the individual migrants collectively created—and then followed— preferential channels due to information both on places and on previous migrations being made available by personal relationships with previous migrants. Although nobody computed any "objective function," thinking of one might help us to understand what happened. It can be understood in terms of "rules for network behavior" (Snijders *et al*., 2010)—which imply social rules of migration; for example, the notion of trying to intensify the use of local, rural resources by migrating to any sort of "close" place.

We have tested the parameters related to our structural hypotheses described in Part 2[27], along with those related to the hierarchical or homophilic effects of the *commune's* attributes that had been found to have important and/or changing effects in our preliminary results. All the tested parameters actually proved to be significant (with rapidly converging models), except for homophily along the Deule river and, more interestingly, the 3-cycles parameter. Our results are shown in Table 3.

The fact that no preference or avoidance of 3-cycles was found, whereas transitivity was clearly significant, might indicate that information circulating "backwards" (to the place of origin) had more influence on migration than information conveyed with migrants to their destination.

[27] Structural "popularity" and "activity" parameters could have been included in alternative specifications, but we chose not to test them as we had no substantive hypotheses on migration that would have explained, e.g., why *communes* with an already diverse in-migration field tended to attract migrants from new *communes*.

The three other structural effects that we considered brought clear answers to our research questions. Reciprocation was in fact barely significant in dynamic models. Although quite a few reciprocated over-attractions had been found in the data—at least in the Flemish-speaking part of the region—they seem to have been driven by other forces than reciprocation *per se*. On the contrary, transitive triplets had significant positive effects and betweenness had a significant negative effect. We thus do not find any increasing "hub" role for stopover towns; contrarily, all our admittedly indirect indicators tend to disprove classical ideas of step-by-step migration as presented in Part 2. We are, however, unable to directly test another variant of this idea of a vacancy chain (migration from A to B being replaced by migration from B to some other places as job vacancies disappeared).

Table 3 about here

The implications of the transitivization parameter are nevertheless very important. It proves the significance of personal relationships with previous migrants, generally implying information is moving backwards and allowing more direct trajectories to opportunities for the youngest generations. Contrary to the simpler reciprocity effect, which proves to be much less significant, it does not only imply migration between places that were previously in direct contact, but opens new possibilities due to the use of more indirect information. The fact that this mechanism was at play in the feedback effects of urbanization on intra-rural moves gives a subtle, non-archaic vision of "moving to a relatively familiar place" as an alternative strategy.

As opposed to "frontier countries" like 19^{th}-century North America, the image of the French rural world is associated with a thousand-year-old populating process (Braudel, 1986) —an image strengthened by the diffusion of small land ownership. It brings about the idea that even though some of their individual members moved out, peasant lineages were anchored around a centre: a type of small family territory which only rural exodus succeeded in uprooting. However, previous findings based on genealogical material already provided a different picture (Rosental, 1999). Peasants who did not own land were peculiar in the sense that they were structurally exposed to mobility. The villagers who came from prolific families — a case which was rather frequent in the North— belonged to a sort of geographically flexible network whose members kept moving over time according to the location of their labor (or sometimes tenancy) contracts. The flexibility of this network without a centre was all the greater while it continued to lose old members (the most remote relatives from a geographical and/or relational standpoint) and gain new ones (through marriages). The data lack any generational depth; we cannot claim that such a pattern at the kin level is the reproduction of the pattern that we have identified at the communal level—especially since the former produced the latter, or vice versa. They are compatible, however, which is useful for understanding important features such as the backward circulation process of information or the general flexibility of the model. There seems to be at least a homology between the two main mesoscopic scales that determined migration patterns, namely kinship and *communes*.

Other case studies would be needed to assess whether these outcomes are specific to our test case or capture more general features of migration. By all means, they show the importance of structural network evolution along with some hierarchical and homophilic effects of attributes. Even clearer than the ERG models, we found the following results:

– a specific attraction increase to the largest cities from middle-sized towns and Flemish-speaking *communes*. In addition, as already mentioned (and still with significant effects, all other things being equal), the out-migration field of communes that were part of the “proto-industrial” cluster in the first period tended to widen, as well as the in-migration field of *communes* that were part of the “urban” cluster in the first period. It is probable that some migration fields had to diversify as older channels and alternative migrations to “close”, "similar" or "familiar" places did not prove sufficient to meet new needs. Naturally, this initial effect faded when industrialization continued to progress.

– a tendency toward homophily according to three different criteria (which were not as correlated as it would seem): cultural (language), socio-economic, and political/administrative homogeneity. The latter might seem surprising, especially since the French *cantons* had been created during the Revolution—a few decades before our period—and ostensibly did not follow previous administrative divisions. *Cantons,* nevertheless, also had military and judicial functions, while markets, fairs, or ceremonies held in the *chef-lieu* were opportunities for their inhabitants to gather (Morel, 1972; Lagadec, Le Bihan, and Tanguy, 2006). *Canton* homophily seems to have been a decreasing driving force, but it did not vanish. Contrary to simple versions of modernization, the effect of language homophily did not fade when literacy increased. Each of these similarities thus regularly eased the opening of new roads for migration (although some older roads were closed at the same time), perhaps for different categories of migrants.

6. Discussion: alternative strategies of migration

Until now, we have been progressively led to focus on intra-rural mobility— which belonged to our initial set of questions—since it has proved to be a central issue in our findings because of its statistical, causal and historiographic preeminence. We must, however, not forget the other important socio-historical factors that were at work within our region. First, after having verified the rural exodus model, we still need to allow for the big cities. The same is true for social stratification within our population. To what extent can we observe different mobility patterns according to the migrants' social situation? Finally, we will have to go back to the relationship between our data and the meaning of our findings: since we have used information extracted from marriage certificates, to what extent do we develop marriage or labor-market effects? It is only after having clarified these issues that we can move to our general conclusion.

The role of the three main metropolises

Our preliminary interpretations have been quite focused on intra-rural migration. We must, however, not forget the fact that Lille, as well as Roubaix and Tourcoing later on, were even more attractive than their population alone would have revealed. They, however, did not indifferently attract migrants from all *communes*, but did so preferably from the middle-sized towns and from the Flemish-speaking region (despite of the long distances implied in the latter case). These two different effects might be related to either two different kinds of migrants and/or middle-sized towns could have served as a stopover for some migrants (as our blockmodeling might indicate). By all means, they point to very specific forms of asymmetry in the network of over-attractions; they are the only hint of modernization as generally envisioned in our models, and therefore provide a rather subtle image of "rural exodus." This pattern considerably echoes what Leslie Page Moch demonstrated at a more microscopic level in her 1983 pioneering work. Through the example of three *communes* sending migrants to the city of Nîmes in 19th-century Southern France, she showed that occupational integration within the city depended on the economic situation of the out-migrating area: in-flows had intermixed migrants from very different backgrounds, implementing a wide range of strategies from the most offensive to the most defensive. What our data show is an extension of this model: Lille, Roubaix, and Tourcoing amalgamated migrants coming from middle-sized towns—some of whom were prone to become skilled workers—and rural migrants from the Flemish villages—some of whom ended up in the most modest occupations.

Considering their ego-centered migration fields actually shows that the three metropolises experienced a cycle starting with an over-attraction on their neighboring area. For Lille, in the second period, this migratory pattern already shifted: the city attracted migrants from both middle-sized, medium-distanced towns and from the Flemish region. To a large extent, Roubaix and Tourcoing experienced a similar change with a time-lag (in the third period)—Roubaix, in particular, tending to rely more on an urban recruiting network.

In our initial questions, we wondered whether the three cities drew their workforce (and rivaled) in the same migratory basins or if each of them had built its own in-migration flows. At this stage, our answer is incomplete and balanced. There was no absolute boundary between their respective areas of attraction: to some extent, but to some extent only, they shared an in-migration field that implied a geographical logic (Lille's attraction was not limited to the Northwest; Roubaix's and Tourcoing's went beyond the Southwest). Their attraction on the Flemish villages, however, had different targets; although, due to the pace of changes experienced by the three main cities, our data are probably not precise enough to provide a clear result on this topic. In order to delve further, we would have to check whether migrants—especially the ones coming from the Flemish region—maintained the same occupations once settled in the three cities. We could not test this hypothesis here, because our sources do not allow us to determine occupations before migration. It is therefore impossible to decide whether differences could have been caused by a diverse selection applied to migrants coming from the same region or by the different occupational structures of Lille, Roubaix, and Tourcoing.

The evolution of the metropolises' migration fields is nevertheless quite similar to the one experienced by Belgian immigrants that we discussed in Part 3. Local, French-speaking migrants were replaced by long distance, Flemish-speaking Belgian migrants in a massive move that seemed to hurt an important historical boundary in that it gave birth to xenophobic acts of violence. This convergence between the changes experienced by foreign and internal immigrants is all the more worth noticing as the literature too often neglects this articulation (Bade, 1980). To some extent, the linguistic boundary played a more significant role than the national one. Instead of competing, migration flows from French and Belgian Flanders (resp. French-speaking areas) were combined.

However, our data do not allow us to continuously follow the process of migration to the metropolises in order to, for example, understand why some Flemish-speaking *communes* sent more migrants to Lille than others. No structural pattern such as transitivization appears in the ego-centered network. Two explanations can be given here. First, the attraction of the main metropolises might have been so powerful and have flown through such public channels of information that it has not followed any pre-existing network pattern. Hägerstrand's model might be irrelevant in a case where a raw "opportunity model" like Stouffer's has such strength. However, the pace of evolution might also only have been too quick to be captured by our sampling scheme. Our information on marriages in Lille, Roubaix, and Tourcoing only covers a couple of months for each period. This discontinuity between the three periods prevents us from finely modeling the evolution of their migration fields, which we could do for the remainder of the sample. Further research is needed to choose between those two explanations.

The social differentiation of migration

Until now, we have only made limited references to the social stratification of our sample. After all, one could argue that all migratory patterns in our area of study are related to the migrants' "human capital". It is true that we have assessed the importance of socio-economic clusters; however, it was only on the basis of imperfect occupational information which did not allow us to take occupation into account before migration. We therefore did not think that it would be very meaningful to derive separate models of migration for spouses declaring different occupations. Using parents' occupations that (sometimes) appear on the marriage certificates would prove to be similarly inutile, as this piece of information is far from systematic and often imprecise when available.

We nevertheless have information on literacy. Previous research has demonstrated that this variable was generally relevant to study geographical and social mobility in 19th century France (Heffernan, 1989; Bonneuil and Rosental, 1999). The rate of literacy rose continuously over the decades, with a time-lag of about one generation between men and women. In the middle of the century, literacy split our sample into two parts so that we could use this segmentation to refine our analysis. We did this for the second period: we extracted data from the moves of illiterate men and estimated the gravitational model for this sub-sample; then, we used a triad census, blockmodeling, and an ERG model to describe the new network of over-attractions, comparing these results to the global results.

They are generally quite similar, but help to verify some of our conclusions. The over-representation of triads, including reciprocity, is even higher. This fits well with the hypothesis that villagers who could not afford moving to the city[28] had to stretch their range of destinations within the countryside, which created (among other patterns) an intensification of reciprocal ties between villages. The global movements of illiterate men in our region followed a somewhat peculiar geographical pattern, with an even stronger density inside the "light-grey-triangles" block within the French-speaking area—which we had already suspected to partially mimic the migratory behaviors of the Flemish-speaking area. According to the ERG model, homophily was even more relevant here than for the entire sample, as shown in both language and socio-economic clusters (except for the

[28] On the relationship between mastering literacy and migrating to the city, see the testimony of Nadaud, 1895, and Corbin, 1971, Moulin, 1986, Rosental, 2004.

“urban” cluster). Finally, the impact of the adjacency effect was much higher than in the global sample, while the processes of attraction of medium-sized towns towards Lille, Roubaix and Tourcoing, as well as from the Flemish villages to the cities, was not significant —a pattern that strongly points to the social differentiation of migration.

These results thus strengthen our idea for a dual model. Even though villagers as a whole intensified their use of intra-rural moves, this was more valid for illiterate men who tried to avoid—or were deprived from—access to the big cities.

Labor market or marriage market?

Is the mobility pattern that we observe structured around the labor market, marriage market, or both? It is difficult to give a precise answer to this question with our data, but it is possible to clarify the mechanisms that were at stake. Did perspective spouses move in order to marry[29], or did they marry someone from their *commune* of residence and work?

Once again, we have chosen the second period to perform a simple test in order to at least partially confront this question. We have defined “marriage ties” in our data as ties between the *commune* where the bride lived just before marriage and that of where the groom lived. We estimated a separate gravitational model on this data (as the number of marriages was likely to be influenced by population and distance), considering the residuals as a network of marriage over-attractions. The gravitational model offered the same coefficients as in the case of migration: marriage and labor migration were influenced in the same way by both population and distance.

[29] Our data actually include a high number of couples who did not leave in the same *commune* at the time of their marriage – which allows us to describe a marriage network in this section. It is however likely that some of the other spouses had moved beforehand, and at least partly in order to find a marriage partner in a new place.

An additional and perhaps bolder move was to subtract our "marriage over-attraction network" (MON) from our "global (migration) over-attraction network" (GON), which gave us a "non-marriage over-attraction network" (NMON) made of those migration over-attractions that were not simultaneously marriage over-attractions. It may be considered as a proxy for the labor over-attraction network.

The triad census of the MON gives results very close to those of the GON, with somewhat more reciprocal relationships. In the ERG model of the MON, the three types of homophily and adjacency are significant; linguistic and *canton* homophily, as well as adjacency, are much stronger than in the model of the GON. The main difference is the absence of preferential ties between the three metropolises, as well as between the Flemish-speaking region and middle-size towns. This might indicate two things: first, many Flemish (resp. urban) migrants to Lille, Roubaix and Tourcoing had married before migrating; second, migration towards these three big cities was considered or enacted as a special move—an indirect confirmation of the fact that intra-rural mobility could be considered to be an alternative to a more radical move.

We also investigated the GON to discover its degree of association in either a marriage network (MON) or a labor network (NMON). QAP-correlations between the networks show that GON was more correlated with the latter (0.79) than with the former (0.59)[30]. In other words, the migratory patterns that we discussed were more driven by labor markets than by marriage "preferences".

As for NMON, parameters capturing the attraction to the metropolises and the homophily inside certain socio-economic clusters ("day-laborers, urban" and "rural") seemed particularly strong, which might seem logical for a labor network. However, linguistic and *canton*

[30] What was actually used in this specific calculation is a modified version of MON, not including the marriage ties that were not correlated with migration ties. In this version, GON is the exact sum of (modified) MON and NMON.

homophily, as well as adjacency, were also significant yet less important than in the MON or GON. These other types of proximity indeed included a socio-economic dimension. Villages belonging to the same *canton,* for instance, had higher chances to be linked by a network of roads and paths or to have access to the same fairs.

These findings, however limited to the second period, suggest a two-step process. In the first phase, villagers chose their spouses in a "familiar" place. For instance, there was no significant over-attraction between grooms living in a big metropolis and brides living in a Flemish village. On the contrary, such over-attractions existed between places of birth and residence at the time of marriage. Of course, this indication is indirect: our data do not distinguish between these two phases of the life-cycles. We can, however, conclude that for many villagers—and even some urban dwellers—moving to the three main cities was all but obvious; they looked around for alternative labor market opportunities. Many of them were still impelled by this specific out-migration, but villagers who managed to find resources on any sort of "proximity" basis remained in the countryside. Our research strategy makes clear that this process was so strong—though invisible to administrative statistics—that it induced the important changes that occurred over time within the network of inter-village relationships.

Historical results and generalization

We tried previously used network methods in order to produce different views of a regional migration field: static and dynamic, local and global, investigating individual moves and relationships between places, structural effects, and modernization theories. We hope that this research strategy will be used in other case studies, especially since it is not data-intensive. Comparing results would of course help to better understand what can be generalized in our findings and what is specific for a linguistically segmented and rapidly modernizing region.

Important general results include the fact that a significant amount of local changes could lead to overall stable aggregate results and are partially visible on maps. This helps to understand the fact that some features of migration that can be deemed “path dependent” are thus connected to the idea of slow change and could still be active in a rapidly changing economic context.

Finally, we have provided two main findings that demonstrate the ability of dynamic structural network analysis to inform macro-historical issues. First, we have precisely described and measured the ability of the rural world to react to the strong attraction of rapidly expanding industrial cities. This question had until now been either ignored due to the lack or imprecision of administrative statistics at a local level, or disregarded by historians who focused on the classical model of “rural exodus” (Poussou, Courgeau, and Dupâquier, 1988). The French historiography has created the notion of *plein rural* (“countryside full capacity”) to describe the period when each village reached its maximal population (often in the mid-19th century), presuming that the communities could do nothing but passively lose inhabitants after that stage. On the contrary, we have demonstrated the agency of the rural world and opened new avenues of research in this respect. We know almost nothing about the dynamic network processes that we have modeled in Part 5, and even less on the meaning of these rural strategies. Understanding whether they represented active attempts to find alternative solutions in familiar surroundings or consequences of the impossibility to move to the big industrial metropolises will request specific investigations.

Second, our findings are all the more relevant because they concern a very poor rural region symbolized by the remoteness of a non French-speaking area in post-revolutionary France—which was quite Jacobinistic in this matter (Weber, 1976). Our results provide an answer to our initial question: how is it that rural out-migration took more than a century to be completed (from the 1840s to the 1960s) while it happened during a couple of decades in most Western European countries? Until now, the answer to this question, which is socially differentiated, was incomplete. To summarize, peasants living in regions of small land ownership, like South-Western France, had already started to reduce their fertility before 1789 because they wanted to avoid the fragmentation or sale of their farms in the context of egalitarian inheritance. The alternative solution to increase the circulation of resources within the family was not limited to small owners but demanded a minimal level of capital—which could give birth to internal tensions and rivalries. Poor mountain areas (e.g., the Alps, Pyrenees and Auvergne), thus made a massive use of temporary migration, especially in the last decades of the 19th century—a time when the complementarity between urban and rural economic seasonalities reached its peak (Moulin, 1986). On the contrary, our region, along with the booming city of Le Creusot (about 172 miles south of Paris), was one of the only places where "rural exodus" had existed as an irrepressible attraction (Châtelain, 1976; Ogden and White, 1989; Rosental, 2006). Even in this case, our data demonstrate that people in the highly populated countryside developed alternative strategies which contributed to the long and now less enigmatic, survival of rural France.

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Appendix: Occupations

It is common knowledge that the Western (Flemish-speaking) part of our sample was, as a whole, more rural and agricultural than the Eastern part. We however lack precise data on each *commune*, apart from the somewhat vague information given in Joanne, 1869. We could look for local monographs in the future; as for now, we have instead chosen to use information from marriage records, namely the occupations of spouses living in each *commune*. They are, however, not easy to code: for example, we would have liked to have an index of industrial and agricultural activities, but it is impossible to accurately divide *journaliers* (day-laborers), *domestiques*, *servantes* (servants) and probably even *ouvriers* (workers, usually with an artisanal or industrial connotation) into these categories.

We instead chose to build clusters of *communes* based on the percentage of literate grooms and brides and of their following exact occupations:

- for grooms: bakers, carpenters, carters, cordwainers, cultivators, day-laborers, farm servants (*domestiques de ferme* and some very close variants), joiners, masons, servants (*domestiques* and *domestiques à gages*), weavers and workers (*ouvriers,* without precision);

- for brides: cultivators, day-laborers, farmers, farm servants (*servantes de ferme* and some very close variants), housewives (*ménagères*), ironers, lacemakers, linen spinners, maids (*domestiques* and *domestiques à gages*), seamstresses, servants (*servantes*), spinners, weavers, and "without occupation" (*sans profession*).

These occupations were by far the most common, altogether including 62% of mentions for men and 82% for women. We based our list on these most common exact occupations, only checking for variants in spelling, but kept separate labels for probable similar occupations (e.g., cultivators and farmers; maids and servants). It is therefore possible that some of these discrepancies were more cultural than economic (similar occupations had a different title in various parts of our region by the spouses and/or city hall clerks).

We used principal component analysis followed by hierarchical clustering (Euclidean metric, Ward criterion, on coordinates on the first 5 axes) to build clusters of *communes*[31]. These clusters exhibit clear spatial patterns (see Figures 1A to 1C). They are also correlated with other attributes, such as total population and percentage of sedentarity or in-migration from out of the sample[32]. Whereas there is no perfect indicator of the socio-economic structure of our *communes*, we chose to include these clusters in our models. In addition, they are interesting *per se* in that they show, for example, changes in rural industrial occupations (linen spinners, lacemakers, etc.) and literacy (see the last cluster for each period). Our clusters (especially but not limited to the first period) often seem at odds with classical depictions of the archaic *vs*. modern or rural *vs*. urban—the opposition between clusters 1 and 2 in the last period probably being the only representation that really fits in such antinomies.

Figure A1 about here

Criteria with v-tests above 2 or below -2 are listed below (labels are very tentative):

Cluster 1 (white squares): *day-laborer villages* – over-represents day-laborers (43% of women, 37% of men) and masons (4% of men); under-represents literate spouses (34% of women, 42% of men), female spinners (0%) and linen spinners (1%), maids and male servants (2%, 3%) and farm servants (0%, 1%), as well as housewives, cordwainers and workers. It is also exclusively French-speaking and over-represents small villages.

Cluster 2 (pluses): *urban* – over-represents farm servants (6% of women, 9% of men), bakers (2%), lacemakers (4%), seamstresses (9%), female weavers (5%) and literate men

[31] Using the R package FactoMineR: http://factominer.free.fr/ (accessed April 30th, 2010)

[32] We had first tested simpler indexes using only the percentage of cultivators or workers, but they gave less interpretable results, both in terms of maps and of correlation with these external data and with network patterns.

(54%); under-represents day-laborers (7% of women, 12% of men), cultivators (12%, 13%) and male servants (3%). It also over-represents towns and includes many spouses not born in *communes* of the sample.

Cluster 3 (grey squares): *proto-industrial* – over-represents linen spinners (11% of women), servants (7% of women, 10% of men), cultivators (24%, 21%); under-represents female day-laborers (9%), ironers, carpenters, masons and bakers (0 to 1%). It is also exclusively French-speaking, exhibits high sedentarity rates, and includes few spouses born outside of the sample.

Cluster 4 (black squares): *worker-servant villages* – over-represents workers (6% of men), maids and male servants (22%, 18%), literate spouses (50%, 57%), as well as female farmers, spinners, ironers and housewives; under-represents day-laborers (0% of women, 9% of men) and female servants (0%). It is also exclusively Flemish-speaking, over-represents small villages, exhibits low sedentarity rates, and includes few spouses born outside of the sample.

Figure A2 about here

Criteria with v-tests above 2 or below -2 are listed below (labels are very tentative):

Cluster 1 (white): *day-laborers, urban* – over-represents day-laborers (27% of women, 21% of men), seamstresses (9%), as well as joiners, ironers, linen spinners and masons; under-represents cultivators (9% of men, 8% of women), weavers (6%, 2%), maids (2%) and servants (5%, 3%), as well as cordwainers and lacemakers. It is also exclusively French-speaking with low sedentarity and many spouses born outside of the sample.

Cluster 2 (grey): *rural industry* – over-represents weavers (15% of women, 27% of men) and male cultivators (19%); under-represents male day-laborers (9%), seamstresses (4%), farm servants (1% of women, 3% of men), as well as lacemakers, spinners and workers. It is also exclusively French-speaking with high sedentarity rates.

Cluster 3 (black): *rural* – over-represents lacemakers (15%), maids (11%) and servants (12% of women, 12% of men), as well as cordwainers, carpenters, male workers and farm servants, and female spinners; under-represents weavers (1% of women, 9% of men), female day-laborers (4%), carters, joiners and ironers. It is also exclusively Flemish-speaking, over-represents small villages, and includes few spouses born outside of the sample.

Figure A3 about here

Criteria with v-tests above 2 or below -2 are listed below (labels are very tentative):

It is worth noting that clusters 1 and 4 are defined in an extremely similar manner to clusters 1 and 3 in period 2. Cluster 3 in period 3, while geographically proximal to cluster 2 in period 2, exhibit interesting differences (e.g., less cultivators).

Cluster 1 (pluses): *day-laborers, urban* – over-represents day-laborers (27% of women, 24% of men), joiners (5%), housewives (6%), as well as ironers and linen spinners; under-represents cultivators (7% of men, 3% of women), weavers (3%, 2%), servants (1%, 4%), as well as carters. It is also exclusively French-speaking with low sedentarity and many spouses born outside of the sample.

Cluster 2 (white squares): *agricultural* – over-represents literate spouses (82% of women, 86% of men), cultivators (15% of women, 26% of men), as well as carters and "without occupation" (22% of women); under-represents housewives (1%), male weavers, bakers, lacemakers and spinners. It is also exclusively French-speaking with many small villages and high sedentarity rates.

Cluster 3 (grey squares): *textile* – over-represents weavers (13% of women, 20% of men), female spinners (5%) and bakers (2%); under-represents male day-laborers (9%), cultivators (7% of women, 12% of men), literate brides (65%), as well as cordwainers and seamstresses. It is also exclusivley French-speaking.

Cluster 4 (black squares): *rural* – over-represents lacemakers (11%), maids (6%) and servants (15% of women, 7% of men), as well as cordwainers, carpenters, male workers and farm servants (13% of men are farm servants) and female cultivators; under-represents literate spouses (58% of women, 73% of men), day-laborers (4% of women, 9% of men), carters and joiners. It is also exclusively Flemish-speaking, over-represents small villages, and includes few spouses born outside of the sample.

Figures

Figure 1

Location of the case study

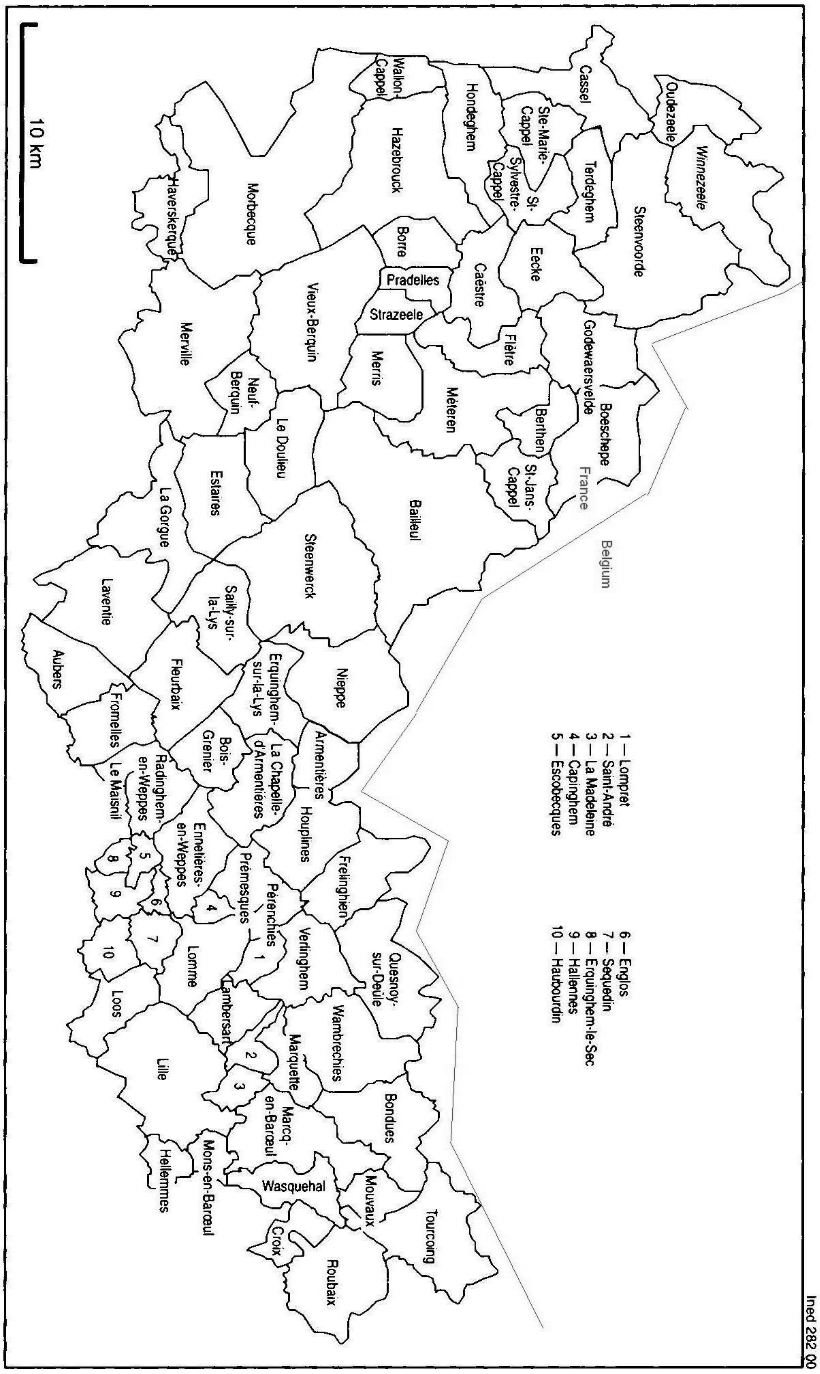


Figure 2

Cassini map of the region

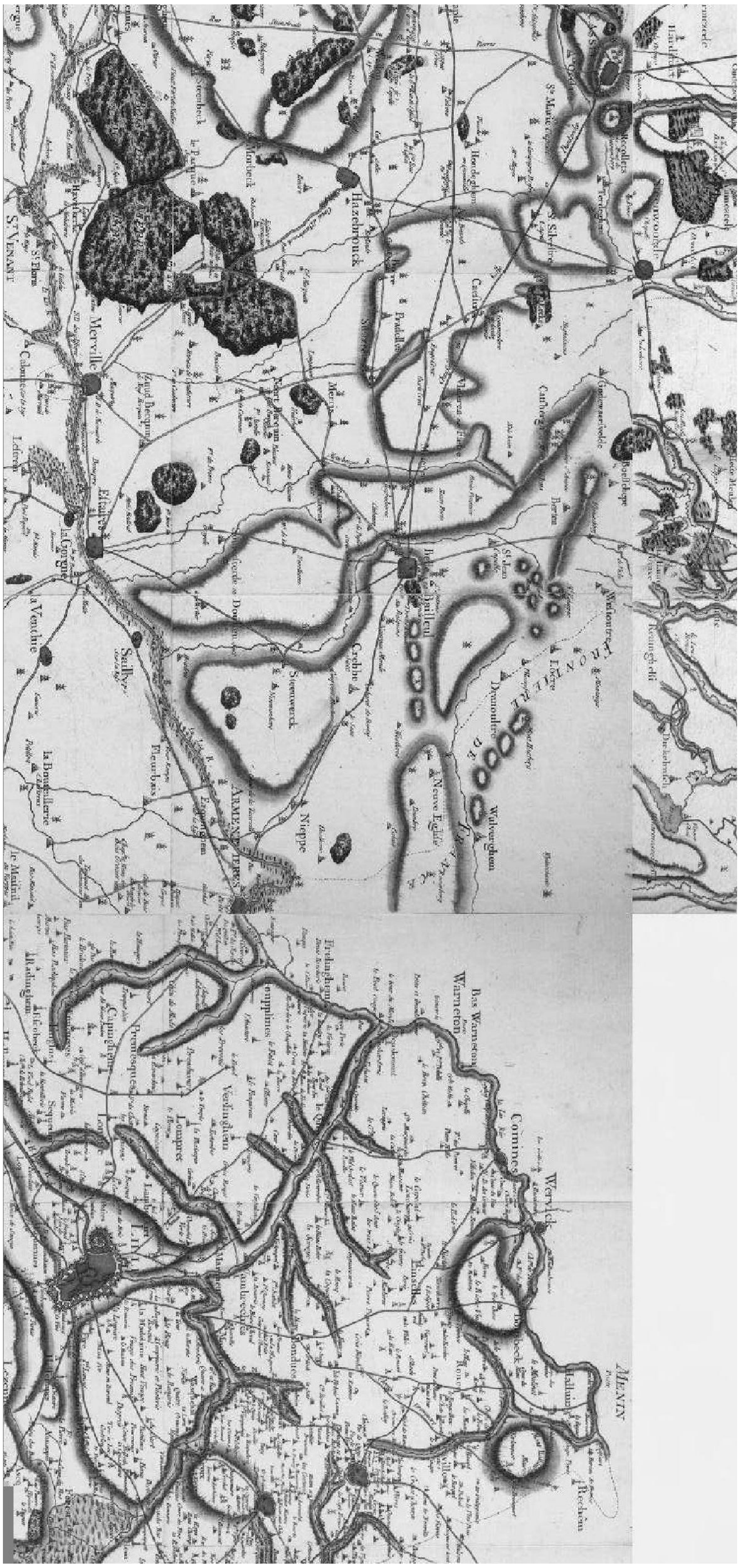
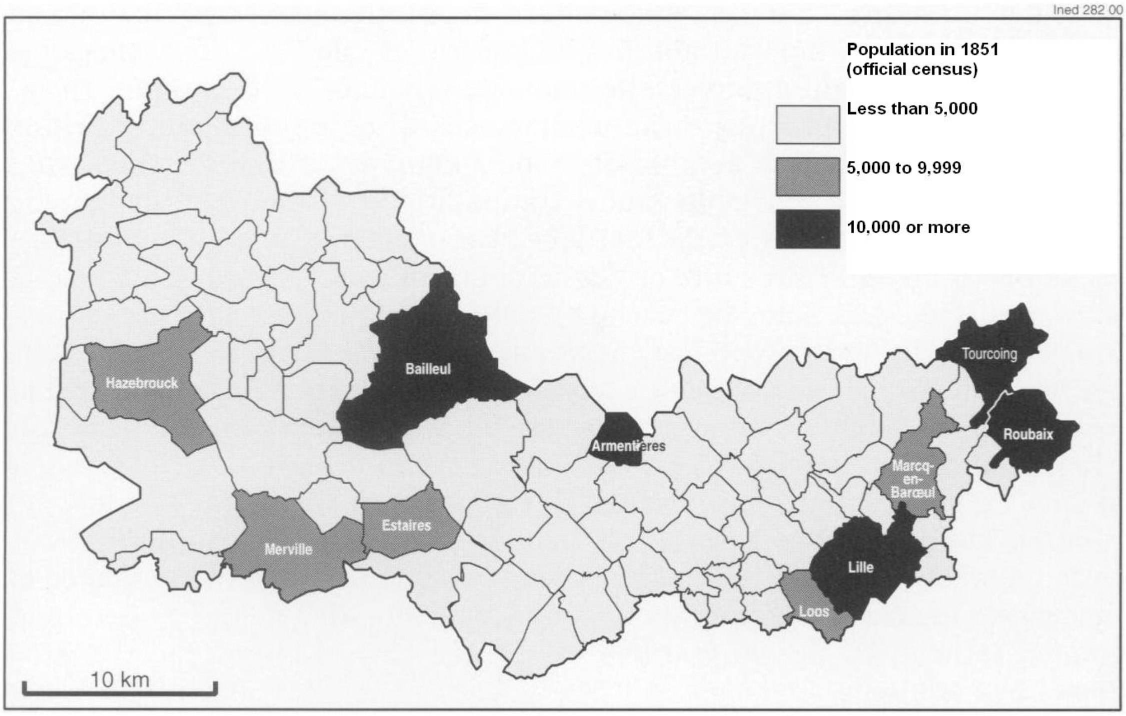


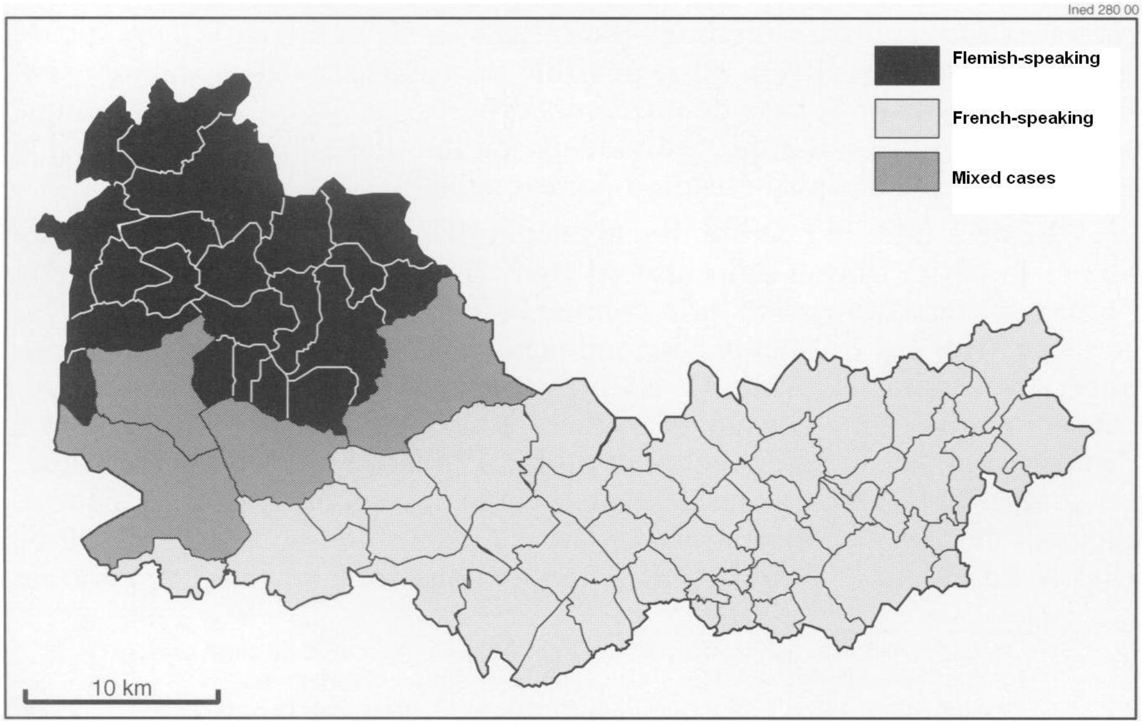
Figure 3

Populations of the *communes*

Figure 4



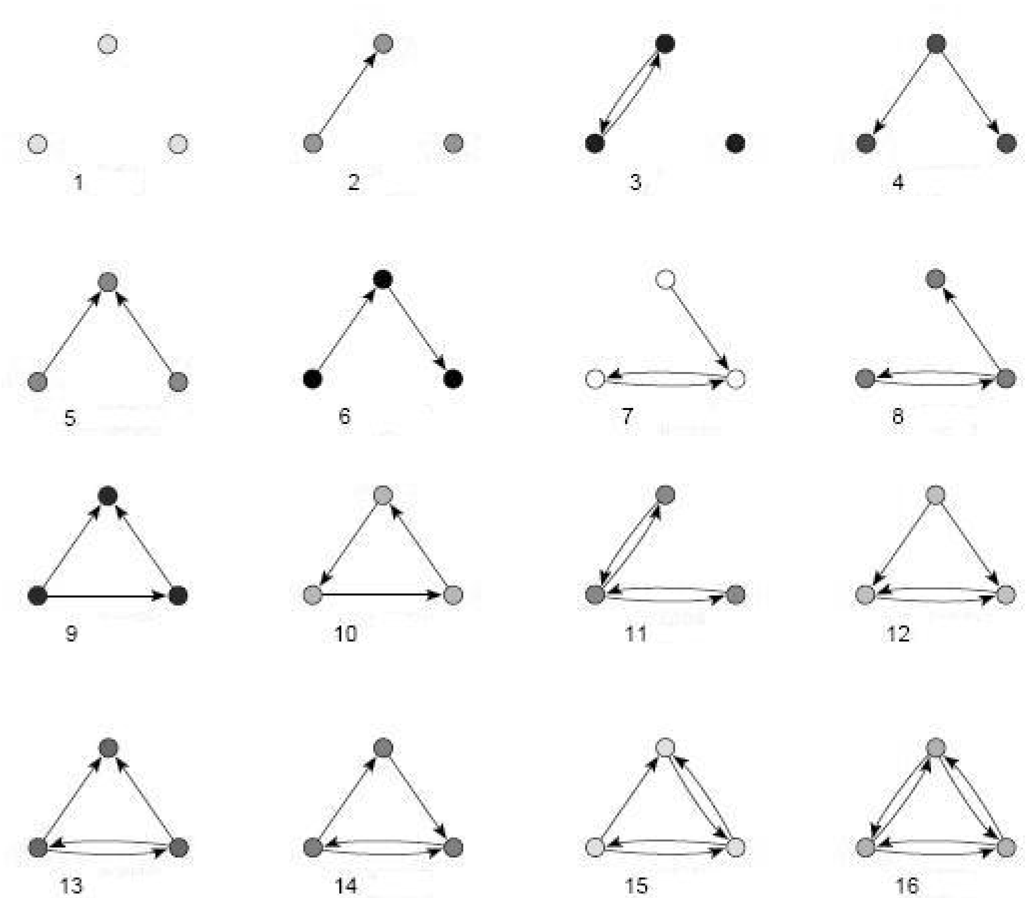
Languages spoken in the region



Sources: Reconstructed from Kurth, 1896 and Coornaert, 1970.

Figure 5

Types of triads



Source: Extracted from de Nooy *et al.*, 2005, p. 207.

Figure 6

Reciprocal over-attractions, first period

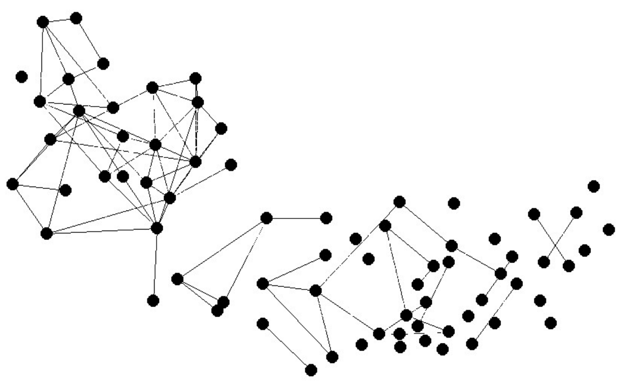


Figure 7

Triads of type 15 or 16, first period

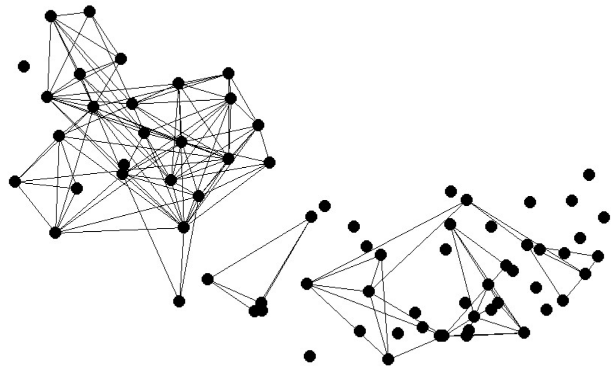


Figure 8

Reciprocal over-attractions, second period

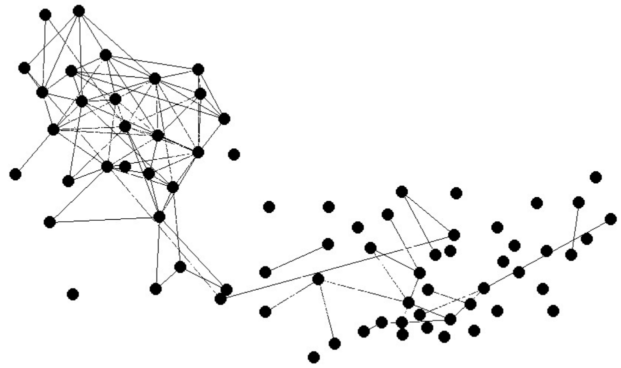


Figure 9

Triads of type 15 or 16, second period

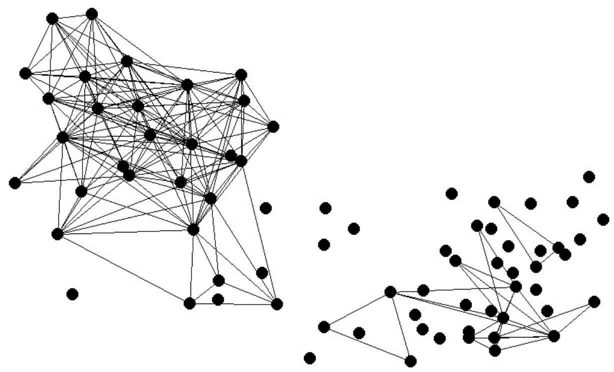


Figure 10

Reciprocal over-attractions, third period

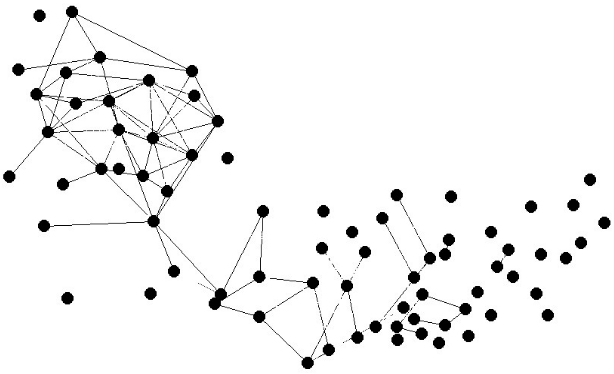
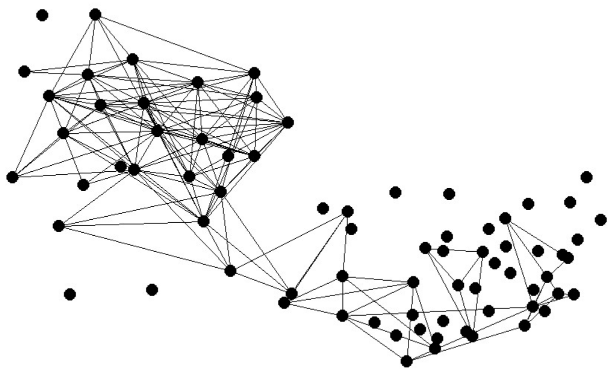


Figure 11

Triads of type 15 or 16, third period



Note: Figures 12 to 14 were originally drawn in colors, which made them more readable. The colored version is available upon request.

Figure 12

Results of blockmodeling, first period

Observed mutual over-attraction frequencies				
Birth \ Marr.				
	7%	0%	0%	
	0%	13%	0%	
	0%	0%	4%	

Observed non-mutual over-attraction freq.				
Birth \ Marr.				
	17%	2%	6%	
	0%	16%	1%	
	2%	0%	16%	

Communes that could not be robustly clustered appear as pluses below

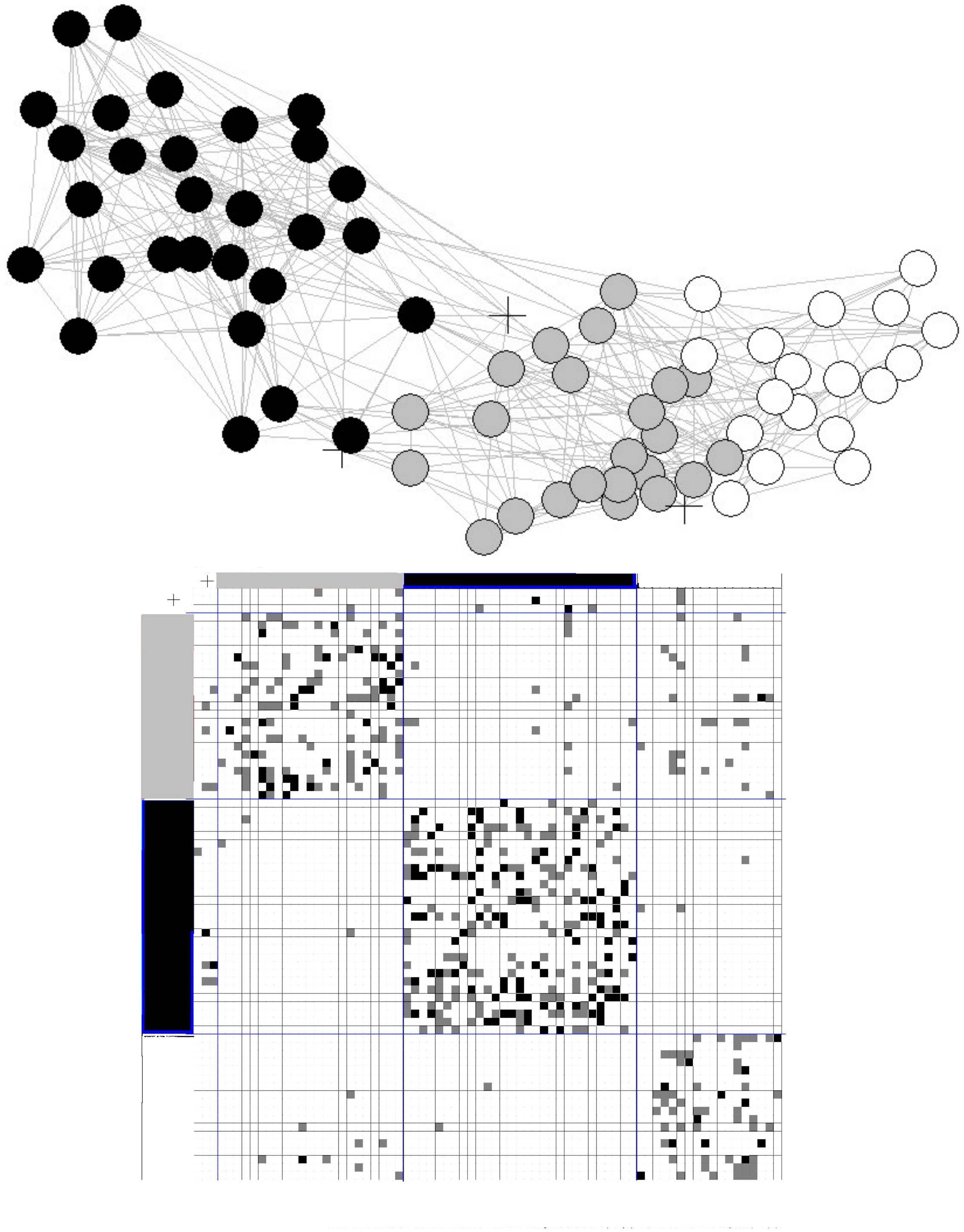


Figure 13

Results of blockmodeling, second period

Observed mutual over-attraction frequencies					
Birth \ Marr.					
Triangles	0%	2%	1%	0%	0%
Circles	2%	7%	1%	0%	1%

Observed non-mutual over-attraction freq.					
Birth \ Marr.					
Triangles	5%	0%	4%	4%	1%
Circles	16%	22%	2%	1%	11%

Circles	1%	1%	30%	0%	0%
Circles	0%	0%	0%	1%	1%
Triangles	0%	1%	0%	1%	13%

Circles	31%	1%	17%	2%	1%
Circles	0%	1%	0%	6%	0%
Triangles	13%	3%	0%	10%	20%

Communes that could not be robustly clustered appear as pluses below

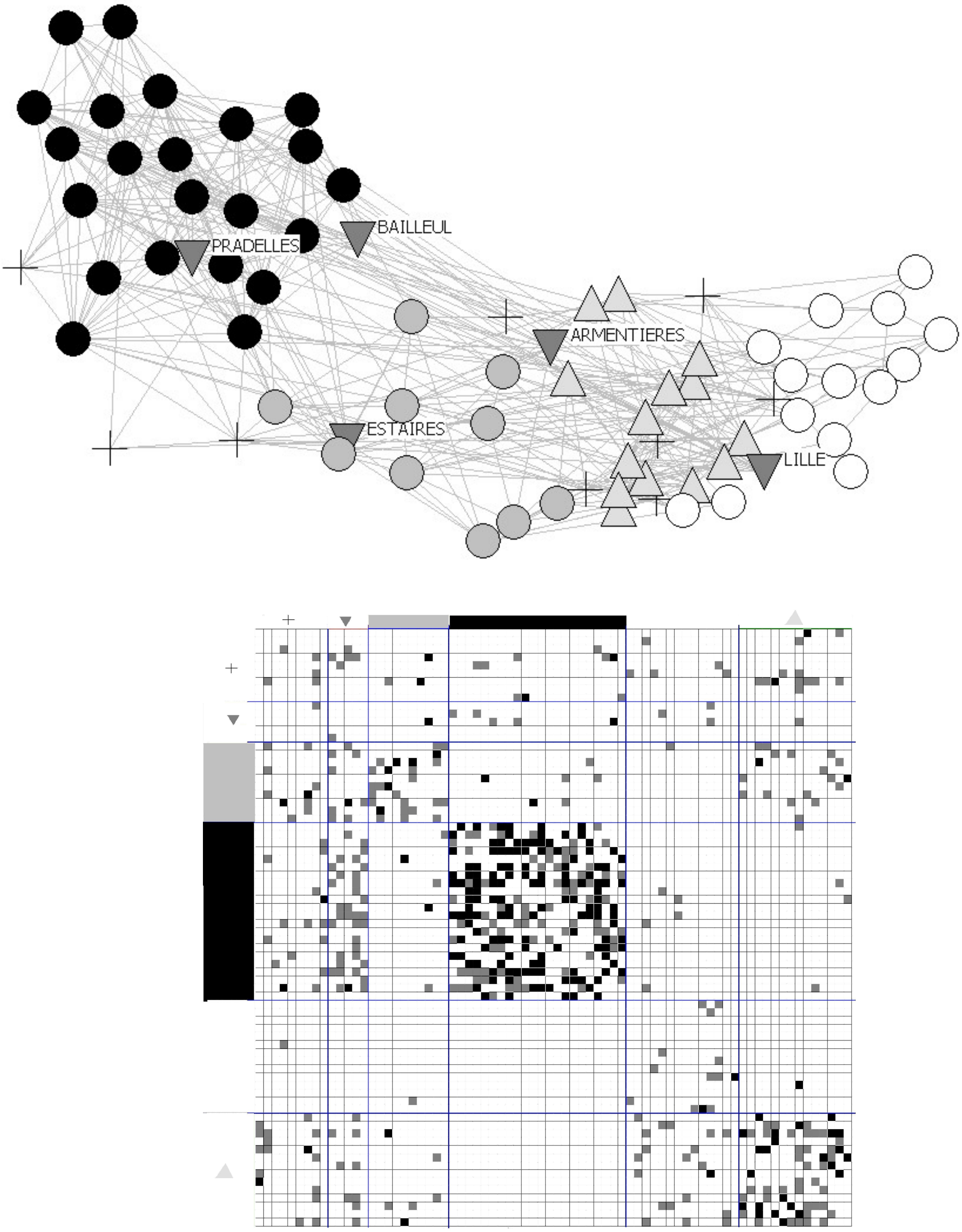


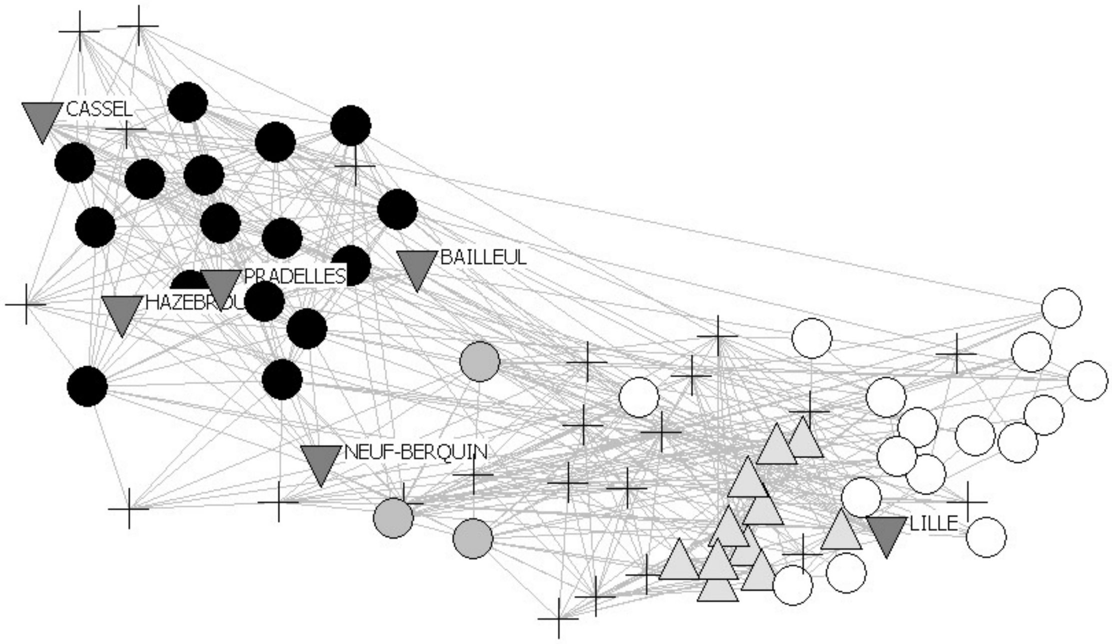
Figure 14

Results of blockmodeling, third period

Observed mutual over-attraction frequencies					
Birth \ Marr.	%				
Triangles	3%	0%	0%	0%	0%
Circles	0%	33%	0%	0%	0%
Circles	3%	0%	32%	0%	0%
Circles	0%	0%	0%	1%	0%
Triangles	0%	0%	0%	0%	15%

Observed non-mutual over-attraction freq.					
Birth \ Marr.	%				
Triangles	13%	17%	3%	6%	2%
Circles	0%	17%	4%	19%	12%
Circles	29%	2%	20%	4%	1%
Circles	0%	0%	0%	6%	1%
Triangles	2%	0%	0%	6%	24%

Communes that could not be robustly clustered appear as pluses below



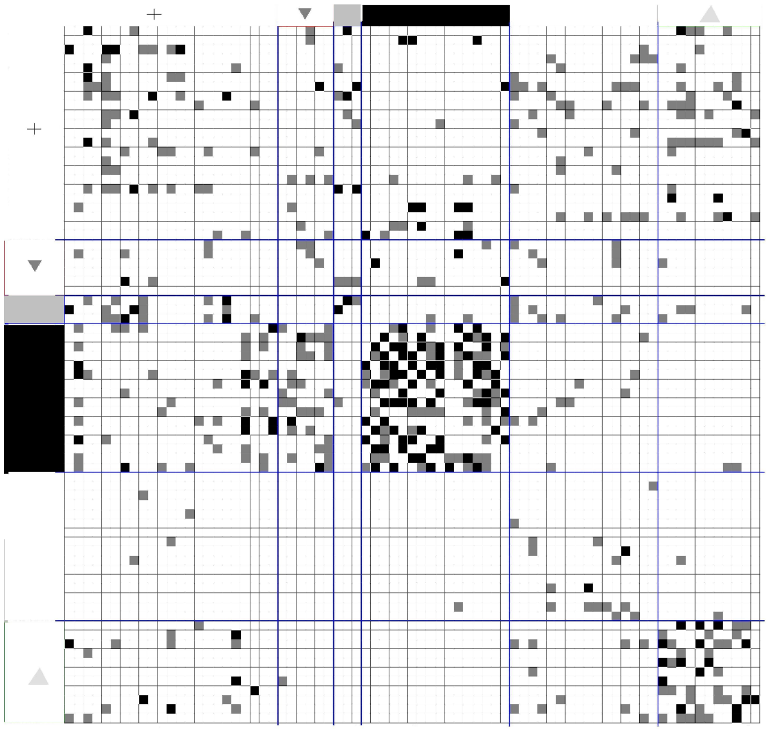
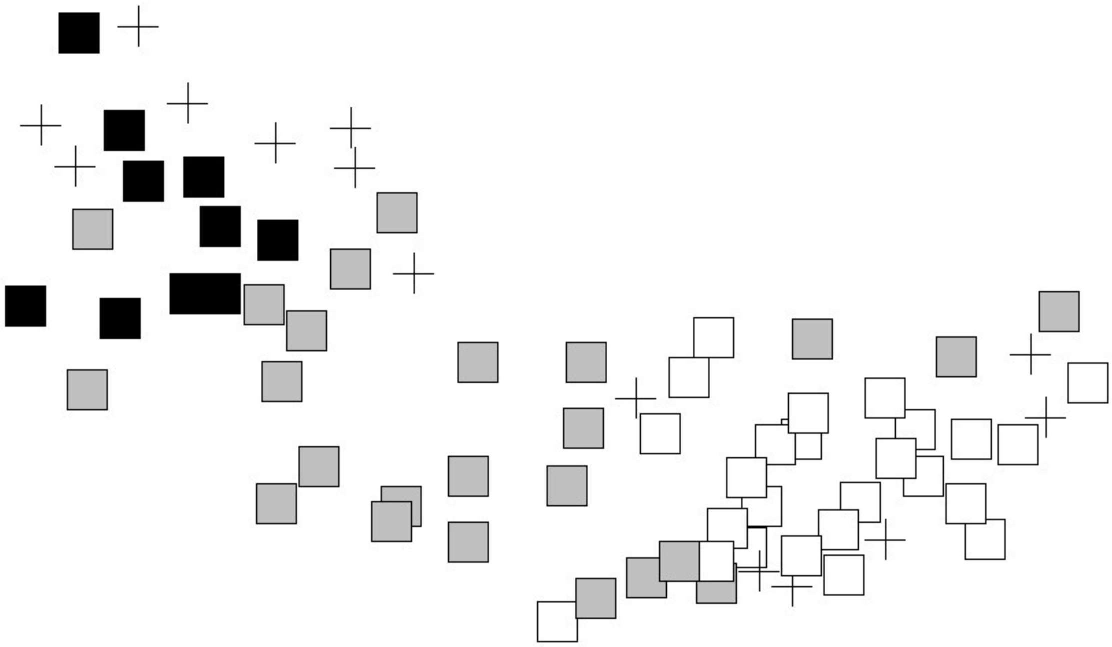


Figure A1

Socio-economic clusters, first period

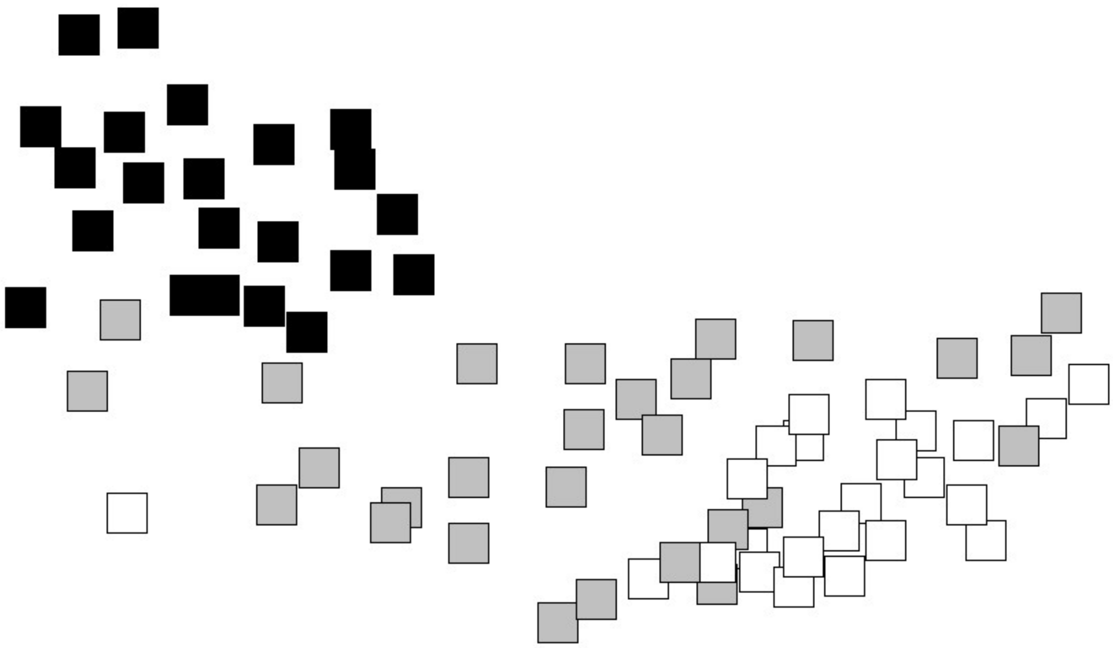


Note: Each square or plus represents a *commune* and they are placed according to geodesic coordinates.

Figure A2

Socio-economic clusters, second period

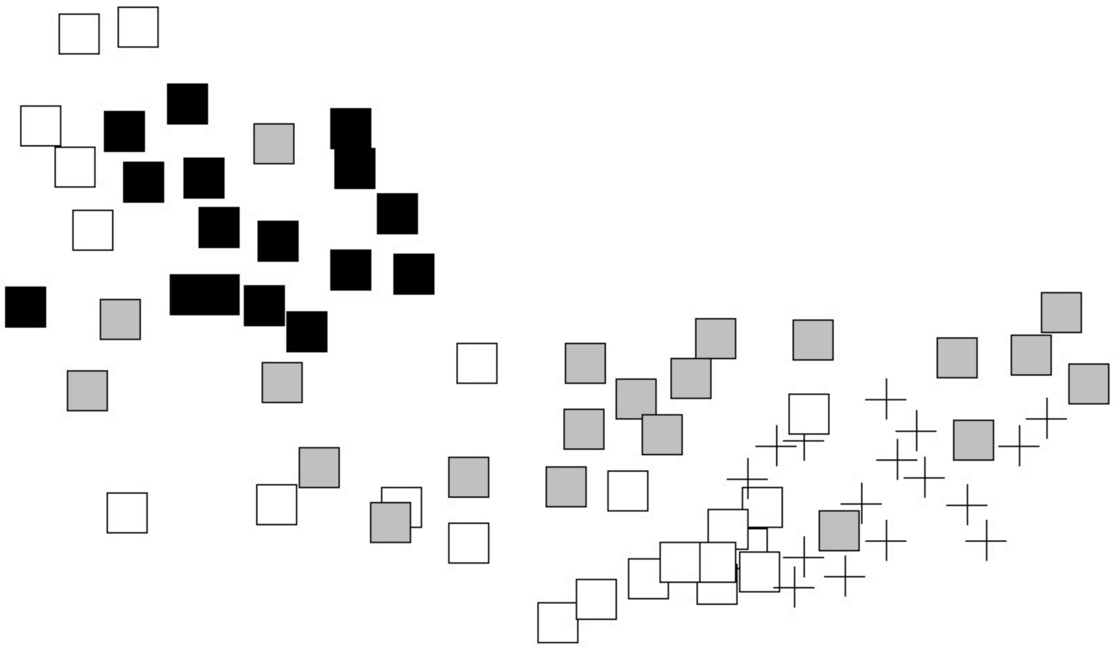
Note: Each square represents a *commune* and they are placed according to geodesic co-



ordinates.

Figure A3

Socio-economic clusters, third period



Note: Each square or plus represents a *commune* and they are placed according to geodesic coordinates.

Tables

Table 1

Observed and expected frequencies of triads

	Period 1		Period 2		Period 3	
Type	Observed	(obs. – exp.)/ expected	Observed	(obs. – exp.)/ expected	Observed	(obs. – exp.)/ expected
1	37201	0.08	38629	0.11	39701	0.08
2	17275	-0.19	17170	-0.25	19278	-0.18
3	4080	2.71	4933	2.97	4163	2.35
4	580	-0.47	683	-0.45	871	-0.3
5	655	-0.4	590	-0.53	647	-0.48
6	828	-0.62	819	-0.67	1080	-0.57
7	394	0.74	371	0.37	356	0.35
8	481	1.12	676	1.5	626	1.37
9	235	0.04	229	-0.15	271	0.03
10	35	-0.54	29	-0.68	33	-0.62
11	85	6.28	136	8.21	87	5.22
12	21	3.37	61	3.13	62	3.43
13	76	5.51	123	7.33	105	6.51
14	107	3.58	126	3.27	93	2.33
15	89	35.98	181	55.24	122	40.15
16	24	579.62	68	1161.88	30	571.72

Table 2

Results of the ERG models

	Period 1		Period 2 †		Period 3	
Parameter	Estimate	Std error	Estimate	Std error	Estimate	Std error
Reciprocity	0.44	0.22	0.54	0.19	0.32	0.21
Alternating out-k-stars	0.29	0.20	0.42	0.17	0.66	0.17
Alternating in-k-stars	-0.04	0.24	-0.21	0.23	-0.36	0.32
Alternating k-triangles	0.75	0.07	0.82	0.06	0.71	0.07
Alternating independent two-paths	-0.18	0.01	-0.16	0.01	-0.14	0.01
Same socio-economic cluster*	0.24	0.07	0.06	0.06	0.18	0.08
Same *canton*	0.26	0.10	0.13	0.08		
Same language	0.26	0.09	0.17	0.09	0.24	0.09
Same position on the river Deule (or not)	0.36	0.12				
Adjacent *communes*	1,66	0.13	1,52	0.12	1,65	0.12
Towns to large cities**	1,79	0.79	1,5	0.44	1,71	0.50

Flemish to large cities***	0.45	0.15	0.48	0.19

† Results for Period 2 should be taken with caution, as convergence was only reached with difficulty and as a result of the inclusion of non-significant parameters. Cluster, language, and *canton* were significant in some slightly different, but otherwise less satisfactory specifications.

* Clusters defined for period 1 are used for periods 1 and 2. Clusters defined for period 2 are used for period 3.

** Period 1: attraction from towns with more than 5,000 inhabitants (in period 1 as well as in 1806) to Lille. Periods 2 and 3: attraction from the same towns to Lille, Roubaix, and Tourcoing. Two *communes* in the vicinity of Lille passed the 5,000 inhabitants threshold between periods 1 and 2, but they were not especially attracted to Lille, Roubaix and Tourcoing: hence this specification, that concentrates on older medium-size towns.

*** Attraction from Flemish-speaking *communes* to Lille, Roubaix, and Tourcoing.

Table 3

Results of the dynamic modeling

	Period 1 to Period 2		Period 2 to Period 3	
Parameter	Estimate	Std error	Estimate	Std error
Rate parameter	17,7	1,33	16,22	1,17
Outdegree (density)	-1.95	0.15	-1.43	0.13
Reciprocity	0.26	0.15	0.25	0.13
Transitive triplets	0.20	0.02	0.12	0.01
Betweenness	-0.06	0.02	-0.11	0.02
Towns to large cities*	1,23	0.48	1,48	0.52
Flemish to large cities*	0.97	0.18	0.89	0.24
Same socio-economic cluster*	0.32	0.08	0.21	0.08
Same *canton*	0.80	0.17	0.40	0.13
Same language	0.39	0.10	0.42	0.11
Migration from cluster 3 in period 1	0.19	0.08		
Migration to cluster 2 in period 1	0.30	0.10		

* See Table 2 for the exact definition of these parameters. “To large cities” means to Lille for the model of periods 1-2 and to Lille, Roubaix, and Tourcoing for the model of periods 2-3. Socio-economic clusters defined for the first period were used for the model of periods 1-2. Socio-economic clusters defined for the second period were used for the model of periods 2-3.