Patterns of Internal Migration of Mexican Highly Qualified Population Through Network Analysis

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Abstract. Many real, social, technological, biological and information systems can be described as complex networks. Nonetheless, few studies treat migration from this standpoint. Some migration studies focus on people, and some others on places. The former require very detailed data, while the latter are based on aggregate data. This study is based on places and uses aggregate data, taking flows as an observable and their resulting patterns are the object of study. Mexican censual events take place every ten years, the most recent on 2010, and it has been only until recently that there are enough capabilities and tools available to visualize and model internal migration to the municipal level. Few studies have focused on analyzing migratory movements of such detail, opting instead for the state level. Network analysis allows the identification of communities with a certain degree of spatial structure, that is, the importance that geographical proximity plays in migration.

Keywords: Internal migration · Complex networks · Social network analysis · Highly qualified human capital

1 Introduction

Many real, social, technological, biological and information systems can be described as complex networks. Nonetheless, few studies have been found that treat migration from this point of view. Notable exceptions are: one focusing on multiscale mobility in the United Kingdom [1] and another one dealing with internal state migration of the United States [2].

Since the decade of the 1990s the study of complex networks and some of its properties have gained importance. Such is the case of scale-free and small-world networks. We want to study internal migration through the analysis of complex networks based on graph theory, where an undirected graph $G = (V, E)$ is defined as a set of V vertices or nodes linked through a set of E edges. This simple construct turns out to be of great utility since it allows the representation of a broad range of real world systems such as: transportation, energy and ecology among others. In social networks, each individual is a node: such as a twitter account or the information flow between

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companies. In this case, as in movement models in general, nodes represent places (metropolitan areas) and the edges (that become arcs in a directed graph) represent flows of people.

Sociologists have studied the interaction between individuals and have created a series of parameters that allow the characterization of the roles each actor plays in terms of their relationships. This is known as social network analysis [3].

In this study focus is given to recent migration, understood as population that in 2005 lived someplace different to the place they lived during the censual moment of 2010, the general population (thus yielding a general population group of people ages 5 or more) and highly qualified population (identifying the population that during the last censual event reported their change of residence and are either studying or have finished college and/or graduate studies).

In 2012, Martínez-Viveros et al. [4] approached the identification of places susceptible to innovation through the characterization of stocks of human capital, measured through the classic indicator of educational achievement as well as the geography of ability (being understood as the contribution of creative occupations). In the study, a significant relationship was found between the indicators of human capital and the concentration of industrial activities with medium-high and high technological base. This implies that the stock of human capital is important for clustering. Nonetheless, the demographic mobility was left out and is presented in the current paper. A classical demographic analysis is carried out in which focus is given to the structure of the general and the migrating population, and differentiating in age and gender groups for these populations, through the construction of age pyramids and specialization indicators.

Furthermore, networks are characterized according to their properties of centrality and clustering into communities. That is, community detection from the interactions that will allow identifying the roles each metropolitan area plays according to their position in their group, and the interactions with the rest of the groups. In this case, the study is restricted to the analysis of 59 metropolitan areas defined by the National Population Council and the National Institute of Statistics and Geography [5].

This paper is structured as follows: the methodology of the study is presented in Section 2, along with a short description of the data used in Section 3. Section 4 presents a discussion on how to characterize human migration while Section 5 looks into the relationship between migration and development. Finally, Section 6 presents a collection of empirical results and conclusions. Throughout the paper, the reader will find that most of the figures can be explored interactively when clicked on the links provided in the figure captions.

2 Methodology

Two main groups of interest are identified for this study: the first, the recent population movements in general and the second, highly qualified migrants defined as those who are studying or have finished a university or graduate degree. Focus is also given to knowledge-intensive occupations presented in Martínez-Viveros et al. [4]. It

is important to note that these flows are expected to be small since they can only be identified if they are part of the labor market. In this sense, a hypothesis is that these flows are subrepresented because the censual definition may not capture intermediate migratory movements, as it only cares if someone changed their place of residence five years before the census takes place.

First, work is carried out with migration matrices in absolute terms and the rate of migration matrix (relative values). These can easily be transformed into networks by creating an edge between metropolitan areas that have flows between each other. Once such a network is created, techniques of social network analysis can be applied to them.

As Bender-deMoll mentions in the network mapping report [6], a classic field of application for social network analysis is the characterization of flows of goods and people. Networks are used to represent flow patterns between sets of entities and constitute a useful analysis of movement structures. Results of some studies on trade flows have shown to provide more knowledge and have helped predict global resources flow between countries. By analyzing data on both forced and voluntary migrations, a strong correlation has been found between the geography and the relationships shown by aggregate flows. In the same way, these flows reflect the social links of migrants, as they may move to places where relatives and/or friends are located, or to places that information networks have detected to be viable for development [7]. Indeed, Massey [8] and Marconi [9] also refer to this behavior citing Hagerstrand´s theories on migration.

2.1 Network Visualization and Characterization

An important characteristic of this study is network visualization. By geographically placing nodes, some network features can be highlighted according to node parameters. It also allows the identification of special structures in the flow patterns. A common practice in migration studies is to aggregate data according to the analysis unit. In this case, starting with the origin-destination matrix, networks are built and then characterized. Furthermore, the square matrix is transformed into an array of minimum information that avoids information redundancy and also allows for the dynamic exploration of flows between metropolitan areas.

Networks are distinguished from other datasets due to their emphasis in relationships. That is, a network has properties that emerge from the links between its elements. This allows the calculation of some parameters that summarize local aspects from the global structure of the network:

Degree distribution. It is one of the most important parameters to characterize a graph. The degree of a node is the number of connections it has to other nodes, regardless of their direction, while degree distribution is the probability distribution of the degrees over the network. Other parameters derived from this one are the degree of entry and the degree of exit which, in a weighted network, correspond to the entry or exit flow in a node.

Node centrality. It highlights aspects of the network structure capturing how close a node is to the rest (closeness) or the role each node plays in the subset of shortest paths of the network (betweenness) [10, 11, 12, 13].

Community detection. Other fundamental elements are network communities. Using connectivity and flows, nodes that are strongly related can be detected. This can be done in two different ways: the first, by identifying cliques or complete graphs that share edges (as in Figure 2); the second, by means of the modularity algorithm [14]. In principle, community detection is possible if the graph is weighted and its weights have a heterogeneous distribution [15].

Brokerage roles. According to Gould and Fernandez [16], there are five possible brokerage roles of nodes according to their position in the group and with respect to other groups: coordinators, itinerant brokers, representatives, gatekeepers and liaisons. These are exemplified in Figure 1.

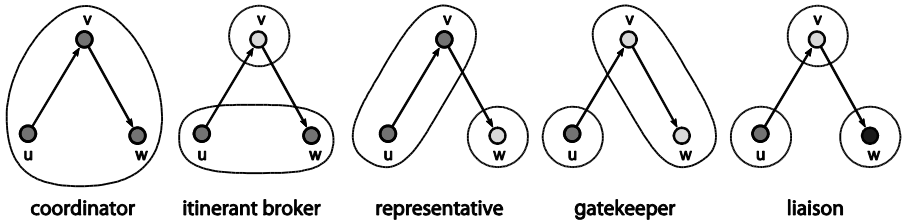


Fig. 1. Possible brokerage roles of node *v* (taken from de Nooy et al. [17])

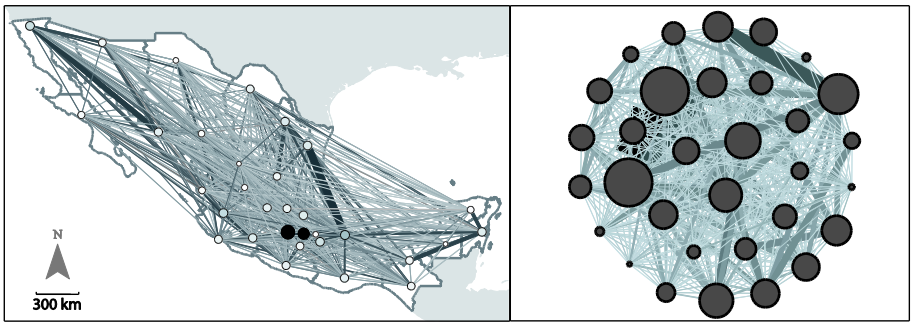
In Figure 1, the role of node *v* is identified according to its position within the group and towards other groups. Of the possible roles, two of them imply the mediation between group members. Firstly, in the coordinator role, the mediator belongs to the group. Secondly, in the itinerant broker case, two members of the same group use an external mediator. The three remaining cases are brokerage roles between different groups described as follows: the mediator acts as a representative of its own group in another one because it regulates the flow of information or goods of its own group. The gatekeeper regulates the flow of information or goods towards its own group. Lastly, in the liaison role, there is a mediator between groups and it does not necessarily belong to any of the groups.

3 Data

Data for this study is taken from the 2010 Mexican General Population Census sample database containing recent migratory movements from 2005 to 2010 between Mexican municipalities. These are aggregated to capture the movements involving 59 metropolitan areas. It is necessary to point out that the censual definition leaves out of the view those movements that take place in a smaller temporal window and that could be relevant given the mobility of highly qualified population. It is also important to note that issues related to sample size are beyond the scope of this report,

even though it is recognized that for some of the groups under study this would have a significant impact.

Mexico is divided into 32 states, constituting the largest aggregation unit of the country. At this scale, a migration matrix is easy to handle. Figure 2 shows the graph corresponding to such matrix. Node size varies with gross migration and line width varies with the amount of flows between entities. This is a uniform graph, since each node has *n-1* arcs. However, many processes are hidden at this scale. The 59 metropolitan areas correspond to the medium scale study in which the municipalities for each area are aggregated. Figure 3 shows the Mexican states and the metropolitan areas considered in this study.



a) Geographic distribution of nodes b) Distribution according to their weighted degree

Fig. 2. Graph of the migration between the 32 Mexican states (source: authors' construction with data from the 2010 General Population Census sample database using Gephi [18])

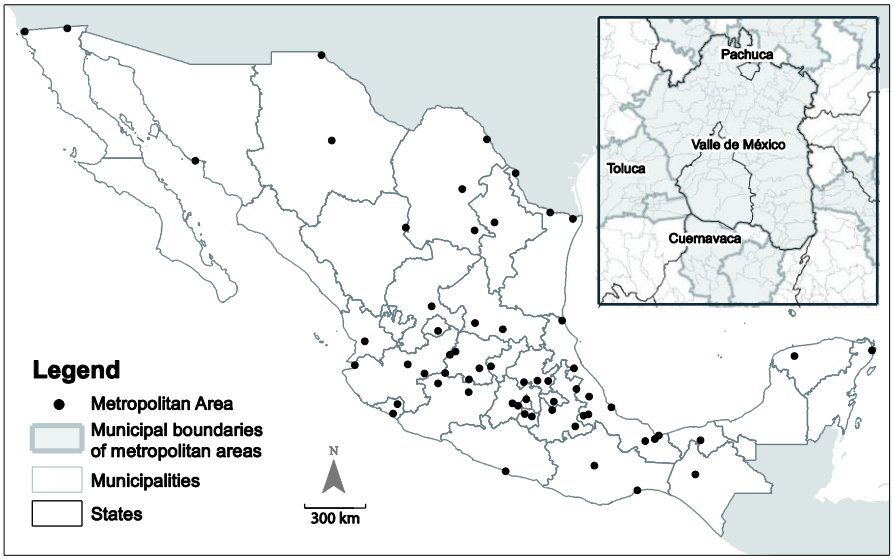


Fig. 3. Hierarchy of Mexico's administrative units (source: authors' elaboration)

4 Definitions to Characterize Human Migration

A *demographic current* is the *flow* that occurs between two territories. The *dominating current* is the most important one, numerically speaking, while the flow with the lower value is called *countercurrent*. Net migration balance is defined as the difference between a current and its countercurrent. The same components used for Elridge's definitions [19] are used in Mexico's censual instruments since 2000, with the restriction that it is valid at the state level. Given that, in this study we drift somewhat away from this definition to focus on recent migration, that is, the population that changed residence between the years 2005 and 2010.

5 Approaches on Migration and Development

Wilbur Zelinsky postulated a model denominated the mobility transition hypothesis, which pretended to complement the general model of demographic transition. He starts with the basic postulate that social scientists try to find patterns and regularities in human activities by means of theoretical constructs which, in the case of Geography and Demography, are rather scarce. That is why he uses the demographic transition (or vital transition) and the laws of migration postulated by Ravenstein in 1885 [20]. According to this model, societies go through different phases of development, depending on their levels of urbanization, industrialization, and scale of modernity. The hypothesis is based on the relationship between different types of mobility and the general development process. It starts from the conceptualization of a diffusion problem and identifies important transformations in the types of migration (change of usual place of residence) and circulation (work mobility). In traditional societies, migratory flows are almost inexistent and as they traverse through the different phases of the demographic transition they also become more modernized, rural-rural migration is no longer the dominant type and instead it favors metropolitan and international migration: "In advanced phases cases can be identified in which at an individual level —people's lifecycle— they also go through a series of movements from education, military service, marriage, work and its implications in different changes and finally, the choosing of a place for retirement" [21].

From economics it is recognized that economic activity is, in first instance, concentrated in the territory by the physical and geographical conditions imposed by such diverse accessibility niches and differential transportation costs. However, on a second instance, it is concentrated by the exploitation of clustering economies. Abel and Deitz [22] analyze if the graduate degrees and Research and Development activities of colleges and universities are related with the human capital in metropolitan areas where they are located. Results indicate that they have a positive relationship, but rather a small one in terms of human capital stock and production, thus suggesting that migration plays an important role in the geographical distribution of human capital. Universities have been regarded as motors to develop local economy, with examples such as Silicon Valley and the Boston route 128 corridor, but also recognized as a fundamental part in the current transition to knowledge-based economies.

There is also the strong belief that by retaining graduates in their ranks, colleges and universities in declining regions can help alleviate their economic sufferings. In fact, they find that the amount of human capital of a region is one of the most powerful predictors of economic vitality [23]. Empirical evidence is explained by the fact that human capital increases productivity and the generation of ideas at an individual level. Therefore, by extension, a higher level of human capital in a region boosts its regional productivity. Given the importance of human capital in economic performance of a region, it is surprising that so little research exists that analyzes the factors that conduct the differences of human capital throughout space.

6 Empirical Results

Two main empirical results of this study are presented: the comparison between features of general migration (population ages 5 and older) and highly educated population and the characterization of each population group's flow networks. All the figures in this section include hyperlinks to interactive online graphics and maps. Graphics were prepared using the Tableau software [24].

6.1 Mexico's Internal Migration and the Migration of Highly Qualified Human Capital

A first relevant element of internal migration is its evolution with respect to previous patterns. In Mexico, during the first half of the 20th century, the first migration attractor was Mexico City and it experienced a huge growth. From the decade of the 1980s, Mexico City's metropolitan area experienced a social decrease. However, flows were mainly directed to municipalities close to the main urban center, thus generating a vast metropolitan area, a pattern that remains up until the beginning of the 21st century [25, 26]. Less is known about the dynamics of other regions in the country, but border cities have also experienced an important growth due to mainly two processes: the establishment of urban-assembly plant corridors and the closeness with the main US border crossing points. In the mobility transition scheme, Mexico is in a recessive phase of the dominant city (the Mexico City basin that shows, back from the 1980 census data, a tendency to repel the central city towards peripheral municipalities and cities nearby).

As far as the general process of vital (or demographic) transition goes, there is a correlation between the population age structure and the change in population education. The distribution of these elements is unequal in the territory since metropolitan areas have a great variation in size and regional preeminence. Population pyramids for ages 20-75 and education level are shown in Figure 4 so it is possible to observe its evolution from 1990 to 2010. As a default, the total for the 59 metropolitan areas is shown but data for each metropolitan area considered in the study can be explored individually. The pyramid shows how population without formal education starts to disappear among the youngest (20-24 years old) and represents less than 0.7%. For the year 2010 the lack of formal education is reported to be almost nonexistent in this age group.

On the left side of Figure 4 the femininity index is shown. This index expresses how many women there are for each men in a given age and educational group. In 1990, women prevailed in the groups with no and basic education. They had a small value, but still greater than 1 (which would mean gender equity) among the youngsters with higher education. However, in the rest of the groups, women were subrepresented. For 2010, the shape of the pyramid is less unequal between the base and the top groups, but the educational advance in both medium and high education as well as gender equity becomes evident. It is also interesting to note that among the younger groups, the disparity between men and women has been reverted.

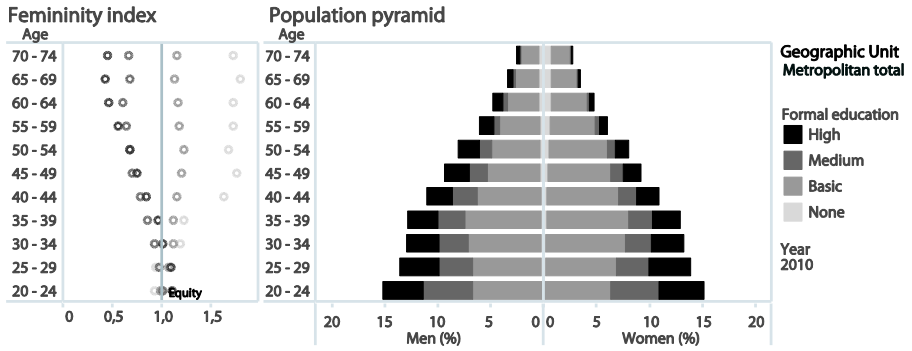


Fig. 4. Population pyramid showing educational achievement and femininity index for 2010 (source: authors' elaboration). Viewable at: *http://public.tableausoftware.com/views/Piram_edad/Dashboard1?:embed=y&:display_count=no*

In 2010, the population of Mexico was around 111 million inhabitants. The vast majority of them did not change their place of residence during the period between 2005 and 2010. However, almost 4 million people did move from one state to another, without taking into account another million people that entered the country from abroad. This implies that the flow of people could, in principle, give rise to a respectable sized city all by itself.

Digging deeper into detail, the municipal division level can be reached and for the year 2010 includes 2456 territorial units. This is translated into 6 million potential flows. Municipalities are the political-administrative units with the largest censual information available and for which it is possible to extract an origin-destination matrix. Table 1 summarizes the information about the percentage distribution of intermunicipal flows, with municipalities classified either as metropolitan or non-metropolitan.

This table allows catching a glimpse of a fundamental difference among recent migration patterns of highly qualified human capital with respect to the general population migration, consisting in the preeminence of flows between metropolitan areas. These flows represent a challenge for future planning: provision of public services, housing, and equipment. There is evidence pointing towards the main explanatory factors being changes in family composition, changes in home income and strategies to deal with day-to-day mobility, as pointed out by Suárez-Lastra and Delgado-Campos in their study analyzing mobility in Mexico City [27].

Table 1. Summary of the 2005-2010 internal migration[1] (source: authors' elaboration)

Municipality	Population ages 5+	University level	Graduate level	University + Graduate level	Knowledge-intensive occupations
Non- metropolitan	846,397 *(13.35%)*	83,220 *(8.45%)*	6,164 *(5.45%)*	89,384 *(8.14%)*	42,871 *(8.95%)*
Moving into a metropolitan area	986,021 *(15.55%)*	141,692 *(14.39%)*	10,354 *(9.16%)*	152,046 *(13.85%)*	49,901 *(10.42%)*
Moving out of a metropolitan area	868,576 *(13.70%)*	112,845 *(11.46%)*	11,729 *(10.38%)*	124,574 *(11.35%)*	55,646 *(11.62%)*
Between metropolitan areas	**1,190,802** *(18.78%)*	**270,326** *(27.46%)*	**36,375** *(32.18%)*	**306,701** *(27.94%)*	**123,793** *(25.86%)*

6.2 Age Composition of Migrating Population

A specialization index by age was built to compare the age structures of interesting migrating groups, taking the structure of the general migrant population ages 20 to 74 as a reference. Figure 5 shows the specialization index in the horizontal axis, values higher than 1 mean an overrepresentation of a group and gender with respect to the same group and gender of the reference population.

The population pyramid of migrants usually has a larger base than rest of the population. That is, younger people usually changes residence more often than the rest. The specialization index reveals that among groups of highly qualified human capital there is also an overrepresentation of the first age groups, from 20 to 50 years old in men, and preeminence among young women with values of the index higher than men. It is also interesting to note that in the case of women with graduate degrees, the index reaches twice the previous value. Not only highly qualified population moves between metropolitan areas, but the general population does as well. Their age equality structure shows a specialization in relatively younger ages. This can be linked to two processes: the absence of an educational offer in smaller metropolitan areas – thus creating the need of younger people to change their residence to continue with education – and the pressure of ejection from the larger metropolitan areas where the labor market can be saturated – as is the case of Mexico City and Guadalajara – towards other regions in which they can insert themselves into the labor force.

The fact of subrepresentation of migrants in the older age groups of highly qualified population could imply that once people are 50 years or older, there is higher work stability.

[1] Non-metropolitan flow occurs between municipalities that are not classified as metropolitan. Moving into a metropolitan area implies the migration from a non-metropolitan to a metropolitan municipality. Moving out is the inverse flow.

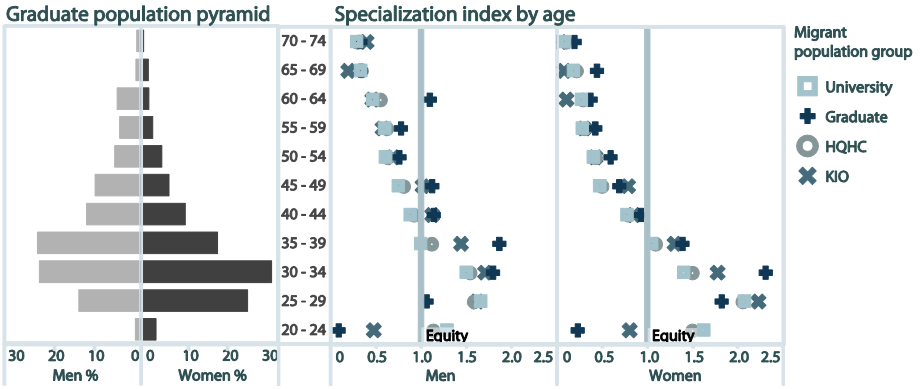


Fig. 5. Graduate population pyramid and Specialization index by age (source: authors' elaboration). Viewable at: *http://public.tableausoftware.com/views/Estructuraetrea/Dashboard1?:embed=y&:display_count=no*

6.3 Gross Migration, Currents, Countercurrents and Centrality

The 8 largest metropolitan areas encompass 50% of the gross migration of population with university or graduate degrees. The net balance for Mexico City is negative for all the groups of interest although the highest disparity is found between immigrants and emigrants with graduate degrees. On the other hand, the volume of highly qualified population in the country's capital city has an important impact in the rates, even if these have the same sign. They reach very small values – about 8 migrants and 6 immigrants for every 1000 person years. The rate instability is also evident in small metropolitan areas, resulting in very high values contrasting with Mexico City. The ten cities with the highest net population migration balance in the university/graduate degree level are distributed across the country: Querétaro, Pachuca, Toluca and Cuernavaca in the central region, Monterrey and Saltillo in the north, Mérida and Cancún in the southeast and León and Aguascalientes in the central-northwest part of the country.

Another interesting thing to note is the behavior of the immigration rate of highly qualified human capital and the general population aged 25 or more: the first is systematically higher than the second. In other words, the mobility of population with university or graduate degree is much larger, relatively speaking.

In order to explore some results of this study, a web application was built to show the flows between different metropolitan areas. An example can be seen in Figure 6. Flow data is handled in JSON format and expressed as a one-to-many relationship, that is, outgoing flows go from one node to many. Each node is identified with an ID, name and geographical coordinates and thus can be put on a map to aid in the study of the spatial interaction between flows. The Leaflet library was used to overlay flows on maps and jQuery was used to handle user interaction, adapting Bostonography's Hubway Trip Explorer [28, 29, 30].

The functionality of this visualization is as follows: the user can click on any metropolitan area (dots on the map) and the migration flows will be shown. Arcs are displayed for incoming and outgoing flows, thus showing the diversity of connections in each network that gives rise to the migrant dominant currents and countercurrents. Clear dashed arcs represent emigrant flows from a hovered node to the selected one, while dark solid ones represent immigrant flows to the selected node. The line width is proportional to the gross migration of the selected metropolitan area.

Migration flows can be explored for people with university degree, graduate degree, university and graduate degree and people in knowledge-intensive occupations. It is also possible to take a look at the pattern of all the flows and get a glimpse of all the possible connections in the network.

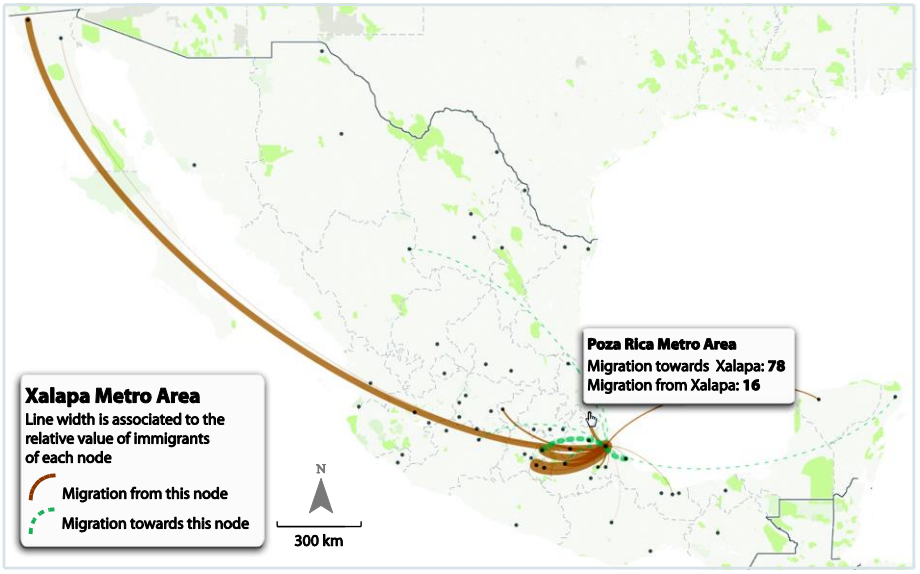


Fig. 6. Migration flows in a web interface (available at *http://rhac2.centrogeo.org.mx/reportes/migracion/migracion.html*)

Another element that can be explored is network centrality. Networks were characterized according to their intermediation, their closeness and the degree of entry and then cross-compared with the typology resulting from the analysis of knowledge-intensive occupations and educational achievement [4]. Figure 7 shows scatter plots of these parameters. Circle diameters are proportional to the gross migration value. The betweenness centrality shows an exponential behavior in relation to the degree of entry and it also shows a good correlation with gross migration. It is important to remember that betweenness is a parameter of the global structure of the network, thus, it changes the position of metropolitan areas according to the population under observation. In the case of the network for the population of 5 years and older, Guadalajara is the metropolitan area with the highest values, while for the rest of the networks, Mexico City always comes first.

The value of *betweenness* centrality for Mexico City's metropolitan area is separated considerably from the rest of the metropolitan areas in the 'Graduates' network. That is, almost any shortest path in that network must go through the country's capital city.

The *closeness centrality* has an inverse relationship, thus a smaller value indicates that the distance from that node to the rest of the network is smaller, therefore making it more central. It can also be seen in Figure 7 that some metropolitan areas under the 'Mean' category are overlapped and these also happen to have a higher centrality value. This result can imply that these metropolitan areas constitute 'in-transit' regions for the formation of human capital, that is to say, they both receive population in their formation years and expel population looking to join the labor market.

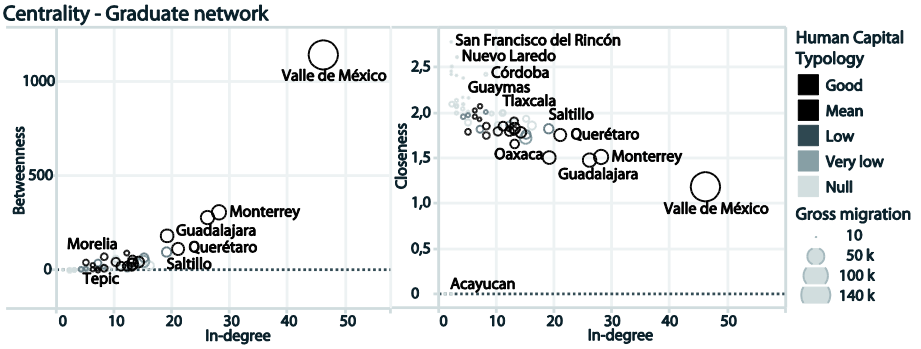


Fig. 7. Scatter plots of the centrality parameters with human capital typology[2] (source: authors' elaboration). Viewable at: *http://public.tableausoftware.com/views/Rolesymontos/Parmetrosdecentralidad?:embed=y&:display_count=no)*

6.4 Community and Brokerage Role Detection

The initial step to determine which role each metropolitan area plays is to classify them in terms of the flow network (absolute values) or immigration rates (relative values). In as much as possible, the number of communities was kept alike to be able to compare their composition in terms of the number of members and their geographic distribution.

The quality of the partition (the communities) turned out to be diverse, ranging from a minimum value of 0.44 for the communities of immigration rates of population having university degree, to a maximum value of 0.66 for the communities of absolute values of population having a graduate degree, implying that some elements could change their membership. This in turn is associated with high values of the intermediation centrality parameter. Some community detection algorithms are based on the elimination of the nodes with the highest betweenness values, resulting in communities with no members playing the liaison role.

[2] The typology captures the concentration of knowledge-intensive occupations and educational achievement for each metropolitan area (Martínez-Viveros et al. [31]).

Another important element is that in many cases, the dominant role of a metropolitan area does not coincide with any of the five types previously mentioned. This means that the node, or nodes, only interact with members of their own community, and even more, they do not act as coordinators. This happens, in general, with the less connected metropolitan areas.

A common element in migration studies is that there is an important spatial component in the flows that is reflected in the communities. This means that, even though some metropolitan areas are distributed along different regions of the country, they have many interactions among them and can be joined in as a community. This happens in the central region of the country, where almost all of the metropolitan areas were classified as part of the same group and is also observed in other parts of the country, as can be seen in Figure 8.

Fig. 8. Communities and dominant brokerage roles (source: authors' elaboration). Viewable at: *http://public.tableausoftware.com/views/Rolesymontos/Comunidadesyrolesdominantes?:embed=y&:display_count=no*

As it was previously mentioned, roles depend on the position of the node in terms of their relationship with other nodes in the same or in a different community. The liaison role implies an intermediation relationship with two communities, that is, each node is important as it keeps brokerage relations among three communities. In the case of the 'University' network for both the absolute and relative values, this is the dominant role for the majority of its members (the exception being Cuernavaca, which for the immigration rates acts as a gatekeeper).

This result ties in directly with the difficulty to create a "hard" classification, because metropolitan areas with very high values of both degree and betweenness centrality have relationships with many other metropolitan areas. The counterpart of liaisons can be either gatekeepers or representatives, the latter being the dominant roles

with higher frequency in the communities that are not in the central part of the country.

Only in the 'Graduate' and 'Knowledge-intensive occupations' networks there are metropolitan areas with dominant coordinator roles. This is relevant because it shows a higher degree of cohesion within the group, or endogamy. There are nodes having more interactions between members of their community than with nodes of foreign groups, which can be an indication that the labor market and the graduate studies offer promote flows to the interior of the communities. Despite that the geographical component is weaker in the 'Graduate' networks this result also ties in together with the size of community "1", which is the community where the highest frequency count of coordinating nodes is found (24 for the absolute values and 22 for the rates). In this scenario, the coordinating metropolitan areas are usually smaller in size and their interactions obey a small scale dominion. That is, they can have a limited regional importance.

This is an initial exercise of an exploratory analysis of social networks that has allowed demonstrating its potential to analyze migration flows. On the one hand, a distinctive feature of internal migration has been exposed, and it is the existence of an important spatial component. The unequal development produces a hierarchy of cities that maintain relatively intense local relations (the exception being the migration network of population with graduate degrees, in which community distribution is more dispersed). Community detection allowed revealing functional distance relationships given a specified migrating group, a key concept when trying to understand the redistribution processes of highly qualified population in Mexico.

Further exploration of some particular metropolitan areas makes it possible to get an idea of the importance of each and one of them by the roles they play in each migrating group. Mexico City's metropolitan area, for instance, has the highest values in all of the centrality parameters thus, its dominant role is as liaison for the 'University' and the 'University+Graduates' networks both in the absolute values and rates. In the case of immigrant rates in the 'Graduates' network, its role changes to gatekeeper as it receives migrants from many metropolitan areas outside its own community and, at the same time, has many relations with other cities within its own group.

7 Conclusions

In this study only one of the demographical components of a population has been explored: internal migration. Zelinsky's hypothesis about transition to mobility has aided explaining some vital transition patterns and their correlation with evolution in education and social growth in metropolitan areas: the higher the education, the higher the mobility. This also explains the stagnation of some metropolitan areas with higher population in the country, such as Mexico City or Guadalajara, which have a stabilized average educational level of the general population, while in medium-sized or small metropolitan areas an improvement in this indicator of human capital is observed. This is relevant because, after acknowledging the deficiencies on the data sources used, with the censual definition of 5-year difference for the regular place of

residence, many intermediate movements are lost. These would provide much more detail on the characteristics of the migration of highly qualified population. Also, there is no information on the motivations of migration.

With respect to network analysis, an important conclusion is that the population with graduate degree has a weaker geographical component in its behavior than the rest of the groups. It will be interesting to try and find factors that explain these results. The betweenness centrality parameter looks promising as a migration predictor, except their relationship is not linear. This is not surprising as in many networks the degree distribution can be best described as a power law, yielding scale-free networks.

Another contribution from the network analysis standpoint, one that is not obtainable with the classical analysis tools, is that besides taking into account the aggregate indicators, it offers a way to obtain clusters in terms of their interactions. This exercise has shown its utility when combining results from network analysis —impervious to *geographical distance* but not to *functional distance*— with the visualization of results in a map. In this way flows are shown to have an important spatial component for some groups. In the case of the 'Graduates' network, it can be seen that since communities are dispersed throughout the country, it implies there is a larger breach between geographical and functional distance in the migration flows of this population group.

Future research includes the combination of network indicators with other social, economic and educational performance indicators to carry out multivariate analyses that would allow associating these factors with the migration process of highly qualified human capital.

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