# Scholarly migration within Mexico: Analyzing migrational movements among researchers using longitudinal bibliometric data

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## 1 Introduction

The academic exchange of ideas can go beyond physical borders. As such, many scholars are highly mobile and their work contributes to technological and economic advances of their host, rather than their origin countries. A growing body of literature therefore focuses on the migration and mobility of scientists and its impact at the international level. However, even though the geographic distribution of scholars is both an outcome of regional disparities and a key source of inequality of opportunities for future generations, little is known about the drivers behind movements of researchers within country borders. Understanding these patterns can shed light on important regional deficits that identify areas of progress and opportunity for investment in human capital. From the public policy perspective, it is in the interest of states to maintain a strong base of highly qualified scholars who can provide innovative and scientific solutions to public issues and collaborate with the private sector. In doing so, governments look for the underlying reasons for migratory movements of researchers and the associated sources of attraction at national and global levels. In order to identify these patterns, we propose an approach to study internal migration of scholars using Scopus bibliometric data. We present our methods to measure migratory movements and the resulting network of mobile scholars within Mexico, as an initial exploratory case.

Mexico is a particularly interesting case for exploratory analysis because a larger share of its mobile population moves internally rather than internationally. Between 2005 and 2010, interstate and intrastate migration represented 3.5% and 3.1% relative to 1.1% of the population moving abroad [12]. Although Mexico is an emerging system of science with several leading universities of Latin America, it is an under-studied case in scientometrics literature. It remains unclear whether scholarly migration in Mexico has increased or slowed down in the last two decades as a result of special socioeconomic conditions, such as government spending on public institutions, social inequality, and alternative jobs in the private sector. This analysis intends to contribute twofold to the literature: first, by re-purposing bibliometric data to analyze internal rather than international migration, second by exploring migrational movements of scholars in Mexico. Although our substantive focus is on Mexico, the proposed methodological framework of re-purposing bibliometric data for internal migration is applicable to a broader context.

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## 2 Data and Methodology

For analyzing international migration of researchers, many studies have relied on bibliometric databases. Recent studies offer proxies for place of residence [5], provide bilateral international migration flows [6], offer a methodological framework for dealing with multiple affiliations [11], and analyze movements of highly mobile researchers and return migration [2]. In particular, Scopus has been widely used to analyze international mobility [10,9] due to its advantages compared to other bibliometric databases. For instance, Scopus provides a wider breadth of records in varied disciplines [7] and offers a more reliable author ID [8] which is suitable for tracking movements of individual researchers [1].

Large-scale bibliometric data allow us to identify migrational movements of researchers in a way which has not been possible with traditional sources of migration data like censuses and surveys. Additionally, bibliometric data provide standardized data, which is suitable for comparative studies. The unit of the data is *authorship record* which is the linkage between an author and a publication. Our data involve 1.1 million authorship records of scholars who have published with Mexican affiliation addresses in sources covered by Scopus. Using the data, we analyze migratory events of over 200,000 researchers between 32 states of Mexico through the changes in their affiliation addresses over the 1996-2016 period.

Prior to the analysis, the data were pre-processed to extract the state of the affiliation institution for each scholar in a given year. First, a state-detection algorithm is used to identify the most likely state from different parts of a given authorship record, such as the address and the name of the institution. Then, these results, combined with manually extracted states for 2200 records, were used as training data for developing a neural network using *Keras* [4] which identifies the state for a given authorship record with an accuracy of 98.9%. After extracting states for authorship records, we format the most likely state of researchers in each year as a tabular data structure in which rows represent individual researchers and columns represent different years. This data structure facilitates creating temporal networks from migratory events.

## 3 Results

During the period 1996-2016, only 7.8% of scholars have moved between states. The data show that the median mobile scholar has actively published for 9 years while its non-mobile counterpart has been active for 5 years. Although Mexico City appears to attract many scholars, the consistent and negative net migration rate in Figure 1 suggests that more scholars have exited than entered. However Jalisco, an important economic state located along the Pacific coast, is an example of a common trend in other states where migration rates vary greatly.

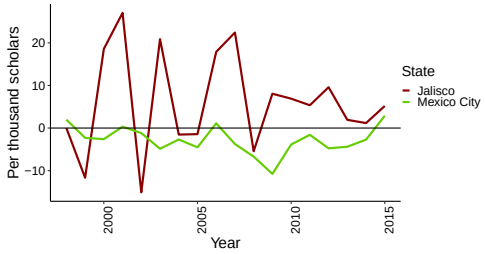
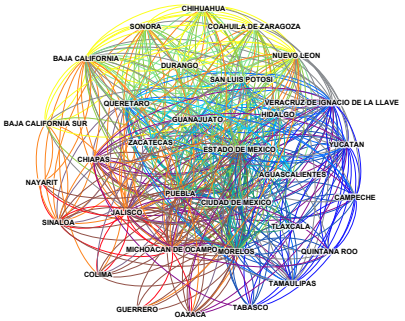
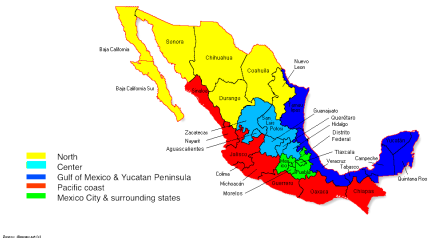



**Fig. 1.** Net migration rates for scholars in selected states

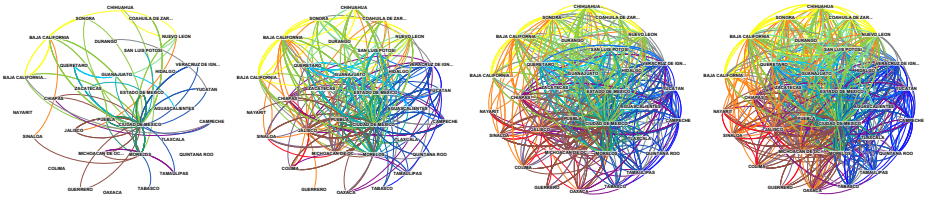
Figure 2 shows the direction and magnitude of migratory movements of scholars in Mexico between 1996 and 2016. The states that receive and send the most scholars include the capital city and its surrounding states (State of Mexico, Puebla, and Morelos), as well as states that contribute the most to national GDP such as Nuevo Leon, Guanajuato, Jalisco and Michoacan. Overall, Mexico City appears to be the main destination and origin of mobile scholars, which may be due to its political and economic importance as well as housing many large national universities and research institutes.




(a) 1996-2016, edges representing movements of 5 people or less are not shown




(b) 32 states of Mexico grouped into five regions



(c) 1996-1997 (d) 2002-2003 (e) 2008-2009 (f) 2014-2015

**Fig. 2.** Network of internal migration among researchers in Mexico in 1996-2016 (a), a map of the colored regions corresponding the nodes of the networks (b) four cross-sectional networks based on selected one-year periods (c-f). Directions of edges are clock-wise and their colors are the mix of respective origins and destinations. Intensity of movements is seen by the thickness of the edges (see the figure on screen for high resolution).

Subpanels (c-f) of Figure 2 highlight the period movements of scholars between states. Overall, the migration network of researchers has not only become more dense but also more diverse over the past two decades. For instance, in more recent years, states along the Pacific coast (red) show a greater exchange (purple edges) with states along the Gulf of Mexico and the Yucatan Peninsula (blue).

Looking closely at Figure 2, we observe a core-periphery structure [3] emerging in the network of mobile scholars. The core is made up of Mexico City, State of Mexico, Morelos, Puebla, Queretaro, Guanajuato, Jalisco, and Michoacan while the remaining states form a periphery. States forming the core are among capital state and surroundings, center states, and Pacific coast states while all state from the gulf and peninsula and northern states are in the periphery. Note that the states that concentrate the majority of scholars in 2016 are Mexico City (and surrounding states), Nuevo Leon, State of Mexico and Jalisco.

## 4 Discussion: A scholarly migration transition?

The changes observed in patterns of scholarly migration between states can be looked at from the perspective of a migration transition model [13]. Similar to the Demographic Transition, Zelinsky identifies five phases whereby spatial and time-specific characteristics (economic, social, and historical) determine mobility patterns [13] in the context of general migration considering different origins, destinations, and direction of migratory events. Although, the model is based on a general population of migrants, the observed network patterns imply that it may have a bearing on mobile subpopulations such as scholars. The migration patterns between rural and urbanized states in Figure 2 suggest that Mexican scholarly mobility is experiencing the phase of a *late transitional society* [13]. Indeed, in this stage migration relatively increases between the urban centers which in turn results in circular migration within a single metropolitan region of the network.

Considering most patterns in network of Mexico scholarly migration to be featuring a late transitional society and given certain conditions, we may speculate that the *advanced society* in Zelinsky's model to be the forthcoming stage of migration transition for Mexico. Migration between urban centers and individual urban agglomerations continues in the advanced society stage such that a lattice of major and minor metropoles will emerge in the network of migrational movements. The emergent core-periphery structure of the network seems to be analogous to the expected lattice of major and minor metropoles suggesting a likely transitioning of Mexico internal scholarly migration into an advanced society.

## 5 Summary and future directions

By studying the changes in the migration flows and rates of scholars between the 32 Mexican states, we offer a general perspective of where scholars are attracted to. We also analyze general traits of scholars such as their number of years of active publication and the main states of origin and destination. Our results suggest that there is heterogeneity in the direction and magnitude of migrational movements among scholars while Mexico City and its surrounding states appear frequently on the paths of mobile researchers. Our work highlights that longitudinal bibliometric data offer valuable insight into internal migration patterns of scholars when coupled with an algorithmic method for producing a sub-national level of aggregation. Future extensions include inferring gender of authors in bibliometric data. In addition, national registries of academics will be added to the analysis to complement the current profile of scholars in Mexico with areas of expertise and types of institutions of affiliation. Common demographic variables such as net migration rates are essential for quantifying migrational movements, but a more comprehensive picture of scholarly migration is obtained when network approaches are deployed as well. Demographic and network approaches complement each other in providing a more comprehensive view on the dynamics of scholarly migration which is consistent with the transitional nature of migration systems.

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