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Industrial Complexes in Mexico: Implications for Regional Industrial Policy Based on Related Variety and Smart Specialization

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GONZALEZ A. V., MACK E. A. and FLORES M. Industrial complexes in Mexico: implications for regional industrial policy based on related variety and smart specialization, *Regional Studies*. The goal of this paper is to identify and analyze the location of industrial complexes in Mexico with the purpose of providing an analytical foundation for the construction of regionally based industrial policies based on the principles of related variety and smart specialization that complement current national-level policy efforts to promote investment and stabilize the real exchange rate. The results of this analysis highlight distinct complexes located in particular portions of the country. The location of these complexes points to several regional policy options that will better address regional heterogeneities in the distribution of industry employment, as well as regional differences in workforce competencies, infrastructure quality and extra-regional linkages than have national level industrial policies.

Mexico Clusters Industrial complexes Industrial policy Related variety Smart specialization

GONZALEZ A. V., MACK E. A. and FLORES M. 墨西哥的工业复合体：对于根据相关多样性及智能专殊化的区域产业政策之意涵，*区域研究*。本文的目标在于指认并分析墨西哥工业复合体的区位，并企图为打造根据相关多样性及智能专殊化原则的区域产业政策提供分析基础，而这些原则补充了当前提倡投资和稳定实际汇率的国家层级的政策努力。本分析的结果，凸显出座落于国家特定部分的截然不同的复合体。这些复合体的区位，指向若干区域政策选项，而这些选项能够更佳地应对产业就业分佈的区域异质性，并较国家层级的产业政策而言，更能应对劳动力能力、基础建设质量和超区域连结中的区域差异。

墨西哥 集群 工业复合体 产业政策 相关多样性 智能专殊化

GONZALEZ A. V., MACK E. A. et FLORES M. Les complexes industriels au Mexique: les implications pour la politique industrielle régionale fondée sur la variété connexe et la spécialisation intelligente, *Regional Studies*. Cet article cherche à distinguer et à analyser l'emplacement des complexes industriels au Mexique dans le but de fournir une base analytique qui sert à élaborer des politiques industrielles régionales fondées sur les principes de variété connexe et de spécialisation intelligente qui complètent les initiatives politiques actuelles menées au niveau national afin de promouvoir l'investissement et de stabiliser le taux de change réel. Les résultats de cette analyse soulignent la présence de complexes particuliers situés dans des coins spécifiques du pays. L'emplacement de ces complexes semble indiquer plusieurs options politiques au niveau régional qui vont mieux aborder les hétérogénéités régionales quant à la distribution de l'emploi industriel, ainsi que les différences régionales des compétences de la main-d'oeuvre, la qualité de l'infrastructure et les liens extra-régionaux que ne l'ont fait les politiques industrielles élaborées sur le plan national.

Mexique Clusters Complexes industriels Politique industrielle Variété connexe Spécialisation intelligente

GONZALEZ A. V., MACK E. A. und FLORES M. Industriekomplexe in Mexiko: Auswirkungen auf die regionale Industriepolitik auf der Grundlage der verbundenen Vielfalt und intelligenten Spezialisierung, *Regional Studies*. Ziel dieses Beitrags ist die Identifizierung und Analyse des Standorts von Industriekomplexen in Mexiko, um eine analytische Grundlage für die Entwicklung von regional basierten Industriepolitiken auf der Grundlage der Prinzipien der verbundenen Vielfalt und intelligenten Spezialisierung zu schaffen, die die derzeitigen politischen Maßnahmen auf nationaler Ebene zur Förderung von Investitionen und Stabilisierung des realen Wechselkurses ergänzen. Die Ergebnisse dieser Analyse verdeutlichen charakteristische Komplexe in bestimmten Teilen des Landes. Aufgrund der Lage dieser Komplexe ergeben sich für die Regionalpolitik verschiedene Optionen, die im

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Vergleich zu den Industriepolitiken auf nationaler Ebene besser auf die regionalen Heterogenitäten hinsichtlich der Verteilung der Branchenbeschäftigung sowie auf die regionalen Unterschiede hinsichtlich der Kompetenz der Arbeitnehmer, der Qualität der Infrastruktur und der extraregionalen Verbindungen zugeschnitten sind.

Mexiko Cluster Industriekomplexe Industriepolitik Verbundene Vielfalt Intelligente Spezialisierung

GONZALEZ A. V., MACK E. A. y FLORES M. Complejos industriales en México: repercusiones para la política industrial regional basadas en la variedad relacionada y la especialización inteligente, *Regional Studies*. El objetivo de este artículo es identificar y analizar la ubicación de los complejos industriales en México con la finalidad de ofrecer una base analítica para la construcción de políticas industriales basadas regionalmente en los principios de la variedad relacionada y la especialización inteligente que complementen los esfuerzos actuales de la política nacional para fomentar la inversión y estabilizar el tipo de cambio real. Los resultados de este análisis evidencian complejos característicos ubicados en zonas determinadas del país. La ubicación de estos complejos revela varias opciones políticas regionales que, en comparación con las políticas industriales de ámbito nacional, responden mejor a las heterogeneidades regionales en la distribución del empleo en la industria, así como las diferencias regionales en cuanto a la capacidad de los trabajadores, la calidad de la infraestructura y los vínculos extrarregionales.

México Aglomeraciones Complejos industriales Política industrial Variedad relacionada Especialización inteligente

JEL classifications: L52, O54

INTRODUCTION

Mexico is one of the most important emerging economies globally and is the second largest economy in Latin America (WORLD BANK, 2014). This prominence in global trade networks is the result of decades of reform initiated in the 1980s, which have transformed the country's economy from an agrarian orientation to a manufacturing superpower (BLECKER, 2014). Despite this transformation, the Mexican economy is not growing as would be expected given its status as a major export economy and its openness to international trade (HANSON, 2010; BOLIO *et al.*, 2014). This suggests that macroeconomic policy alone is not enough to promote high and sustained economic growth (MORENO-BRID and ROS, 2009).

Several explanations have been offered for this stagnant growth including: unsuitable credit markets, a large informal economy, an unsatisfactory regulatory environment and direct competition with China in labour-intensive manufacturing (HANSON, 2010). The emphasis on trade liberalization and globalization have also resulted in a manufacturing-oriented economy with the majority of producers specializing in end segments of the value chain, which are involved primarily in assembly activity that requires little technological sophistication (LÓPEZ, 2012). A recent study by the World Economic Forum categorizes Mexico as an economy in transition that is somewhere between a stage 2 'efficiency drive economy' and a stage 3 'innovation driven economy' (WORLD ECONOMIC FORUM, 2013).

Thus, the challenge for the country is to move from a production-oriented to a more knowledge- and innovation-driven economy (MORENO-BRID, 2013). The pathways towards this needed transformation of the Mexican economy are unclear at this juncture. Prior work on industrial policy in Mexico highlights the lack of any regionally based policies that leverage current industrial competencies (GALLAGHER and SHAFAEDDIN, 2009; LÓPEZ, 2012). In this regard, work on formulating regional policy based on the principles of related variety (FRENKEN *et al.*, 2007) and smart specialization (MCCANN and ORTEGA-ARGILÈS, 2013; BOSCHMA, 2014) suggest new avenues for constructing regionally based industrial policies in Mexico. However, the majority of studies analyzing the contribution of these principles to regional competitiveness are largely European in context (BOSCHMA and IAMMARINO, 2009; ASHEIM *et al.*, 2011). Thus, the value of these principles in creating regional policies in new geographic contexts remains an understudied aspect of this literature.

Given this research need, the goal of this paper is to identify and analyze the location of industrial complexes in Mexico with the purpose of providing an analytical foundation for the construction of regionally based industrial policies based on the principles of related variety and smart specialization that complement current national-level policy efforts to promote investment and stabilize the real exchange rate. Results of this analysis highlight distinct complexes located in particular portions of the country. The location of these complexes points to several regional policy options that will better address regional heterogeneities in the distribution of industry employment, as well as regional differences in workforce competencies, infrastructure quality and extra-regional linkages than have national level industrial policies.

INDUSTRIAL CLUSTERS, COMPLEXES AND VALUE CHAINS

The idea of industrial complexes is rooted in cluster-oriented strategies for enhancing competitiveness. Before moving forward with a discussion of the problems and prospects of clusters, however, it is necessary to define and differentiate industrial complexes from

related concepts including clusters, value chains and industrial districts. This study defines industrial complexes as economically linked firms via value chains that are also spatially concentrated in a particular geographic area.[1] Value chains are defined as industries linked via exchanges in commodities or services (FESER and ISSERMAN, 2009).

While PORTER (1998) has defined industry clusters as geographically concentrated and interconnected companies, the spatial extent and scale of this geographic concentration, as well as the means for determining the interconnectedness of industries, is vague (MARTIN and SUNLEY, 2003).[2] In an effort to add clarity to this concept, FESER and ISSERMAN (2009) suggest two dimensions, one economic and one geographic, to the cluster concept. They assert that economic clustering indicates relationships between businesses without consideration of the location of these relationships, while geographic clustering speaks to a spatial concentration of related businesses.

Industrial districts are a related concept to both clusters and industrial complexes. While there are a variety of definitions for industrial districts, there is some agreement as to their defining characteristics. Many of these characteristics are based on the industrial district in the Emilia-Romagna region of Italy, which is characterized by small firms with backward and forward linkages, dense firm networks, vertical disintegration, and district-specific governance structures (MARKUSEN, 1996). In an effort to generalize these features, RABELLOTTI (1995) highlights four characteristics of industrial districts: (1) spatial concentrations of small and medium-sized firms; (2) connections by backward and forward linkages, as well as non-market dependencies; (3) a common social and cultural background; and (4) a network of private and public institutions that support economic entities within the district.

While related, industrial complexes are conceptually distinct from clusters because they provide a more explicit means of determining the geographic concentration and economic relationship between co-located firms via purchases and sales as outlined in input–output tables. Complexes are also conceptually similar to industrial districts because both consider the connection between firms via forward and backward linkages. However, complexes are distinct from industrial districts because they do not *explicitly* consider the social, cultural and institutional context in which co-located firm operate. They also do not *directly* consider non-market dependencies between firms.

CLUSTERS AND ECONOMIC DEVELOPMENT

Although industrial complexes are distinct from both industrial districts and clusters, the cluster literature is relevant to understanding the advantages and disadvantages of industrial complexes. Prior work has highlighted that the benefits of geographic co-location include: access to specialized inputs and employees, access to information, access to institutions and public goods, and complementary products for buyers (PORTER, 2000). Clusters are also of value to businesses because spatial proximity gives member firms access to valuable local industry information or 'local buzz' (BATHELT *et al.*, 2004; STORPER and VENABLES, 2004).

Clusters are not without their downsides, however. One downside is the increase in production costs associated with successful clusters (PORTER, 1998; MARTIN and SUNLEY, 2003). Research notes that these rising costs may place labour-intensive clusters at a cost disadvantage to lower cost producers around the globe (MARTIN and SUNLEY, 2003). A second downside to clusters is the inherent regional specialization they foster. This rise in specialization can be problematic because specialized cities can be less innovative and can have higher exposures to sectoral trends and volatile growth related to technological change (DURANTON and PUGA, 2000). Third, clusters too reliant on local tacit knowledge and incremental learning may be unable to adapt to rapid changes in technology and other market forces (AMIN and COHENDET, 1999).

In addition to the general advantages and disadvantages with clusters, studies of cluster life cycles (BRENNER and SCHLUMP, 2011; INGSTRUP and DAMGAARD, 2013) and evolutionary perspectives on clusters (MARTIN and SUNLEY, 2011) highlight the need to consider the temporal dimension to clusters in stages (development, expansion, mature and decline), which are important to identify and consider in the design of cluster policies (BRENNER and SCHLUMPF, 2011). A characteristic of clusters that impacts on their evolutionary trajectory is their connection to large, global networks (CRUZ and TEIXEIRA, 2010). BERGMAN (2008), for example, suggests that clusters susceptible to cycle phases are those with a global (traded) rather than a regional (non-traded) orientation.

In this sense, it is important to think about upgrading to ensure the vitality of a cluster over its life cycle. Cluster upgrading is defined as making higher quality products, the ability to make products more efficiently or the ability to move into production areas that require higher skill levels (GIULIANI *et al.*, 2005). Four kinds of upgrading are possible: process upgrading, product upgrading, functional upgrading, and inter-sectoral upgrading (HUMPHREY and SCHMITZ, 2002). Inter-sectoral upgrading in particular involves expansion into different types of productive activities (HUMPHREY and SCHMITZ, 2002). This diversification toward greater sophistication in the production of goods requires models for technology transfer or technology strategies that allow for greater economic complexity (HIDALGO and HAUSMANN, 2009). Agreements with transnational corporations that dominate global value

chains may also be used as catching-up and leapfrogging strategies to upgrade value chains more quickly (CHEN and LI-HUA, 2011).

INDUSTRIAL COMPLEXES AND INDUSTRIAL POLICY IN MEXICO

The extent that cluster upgrading occurs, however, depends on the nature of the relationship between buyers and suppliers in value chains (HUMPHREY and SCHMITZ, 2002). Therefore, the evaluation of industrial complex locations in this study, as well as the position of these complexes in global value chains, is a key consideration for future Mexican industrial policy. This section will highlight the national-level emphasis of prior industrial policy, which appears to be insufficient alone to address the unique regional differences in workforce competencies, infrastructure quality and extra-regional linkages within the country.

Brief history of industrial policy[3]

Prior to 1940, agriculture remained an important sector for the Mexican economy (MORENO-BRID and ROS, 2009). As of 1940, agriculture still comprised 22% of the country's output (GALLAGHER and SHAFFAEDDIN, 2009). From 1940 until the second half of the 1970s, however, Mexico pursued import substitution as a means of fostering industrialization (MORENO-BRID *et al.*, 2005a). In this period, the country pursued a sector-specific national industrial policy with an emphasis on manufacturing automobiles, computers and pharmaceuticals (MORENO-BRID *et al.*, 2005a). State-owned companies were prominent at this time; 41 out of 49 sectors contained state-owned companies (MORENO-BRID *et al.*, 2005a). In the late 1960s, *maquiladoras*, or export-processing zones, were established in the US–Mexico border region in industries such as apparel, automobile assembly and electronics (ROS, 1993; GALLAGHER and SHAFFAEDDIN, 2009). From the 1980s and into the 1990s, however, trade liberalization was pursued without any directed national industrial policy (GALLAGHER and SHAFFAEDDIN, 2009; LÓPEZ, 2012).

In the pre-North American Free Trade Agreement (NAFTA) period (1985–94), national industrial policy moved from sector-specific efforts to a non-sector specific, horizontal approach, and the economic reforms of the Madrid administration emphasized privatization, trade and financial liberalization, and the deregulation of foreign direct investment (FDI) (MORENO-BRID *et al.*, 2005a). This horizontal approach continued with President Salinas' administration, which emphasized trade. These aims aligned with increased efforts at promoting international trade after the passage of NAFTA in 1994; at this time Mexico joined the Organization for Economic Co-operation and Development (OECD) and signed free trade agreements with several countries (MORENO-BRID and ROS, 2009).

Since NAFTA, presidential administrations have been more consistent in pursuing sector-specific industrial policies. In the Zedillo period (1994–2000) policies were launched as part of the Program for Industrial Policy and Foreign Trade (PROPICE), which reoriented policies towards industries with export potential (i.e., textiles, automobiles, electronics, canned foodstuffs) (MORENO-BRID *et al.*, 2005a). Programmes in this administration also focused on the reduction of taxes on foreign inputs through programmes such as the Programa de Importación Temporal para Producir Articulos de Exportacion (PITEX) and Empresas Altamente Exportadoras (ALTEX) (MORENO-BRID and ROS, 2009).

The Fox administration (2000–06) reaffirmed the sector-specific industrial focus of the previous administration through the National Plan for Development, which emphasized industry-specific programmes to enhance competitiveness in international markets (MORENO-BRID *et al.*, 2005b). Recent efforts of the last two federal administrations (Calderón 2006–12 and Nieto 2012–18) have also attempted to create more strategic industrial policy efforts. Recommendations for industrial policy during current President Enrique Peña Nieto's (2012–18) presidential campaign highlighted the need to maintain and strengthen specific manufacturing sectors in which Mexico has a comparative advantage, such as the electronics, aeronautics and automotive sectors (MORENO-BRID, 2013). Additional evidence of the current administration's commitment to industrial policy is the recently passed Law for the Promotion of Competitiveness and Productivity in March of 2015 (OFICIO No. SELAP/300/2280/14, 2014).

Industrial policy and foreign competition

An unfortunate externality of Mexico's industrial policy is that it places the country in direct competition with China and other low-cost countries across Latin America in manufacturing and labour-intensive activities (FEENSTRA and KEE, 2007; MESQUITA, 2007). Case studies of the manufacturing and electronics assembly clusters in Puebla and Guadalajara, respectively, reveal a loss in the number of local suppliers in favour of global suppliers (ALTENBURG and MEYER-STAMER, 1999). More recent studies of Mexican exports have found that China eroded Mexico's market share of exports to the United States in the mid-2000s (GALLAGHER *et al.*, 2008; KAMIL and ZOOK, 2013).

While Mexican exports appear to have recovered since 2009 due to increasing Chinese wages, stagnant Mexican wages and Mexico's proximity to the United States (KAMIL and ZOOK, 2013), suggest the threat from low-cost competitors is unlikely to disappear. Given the tenuous sustainability of low-cost

competition, Mexico will need to move to higher-value-added manufacturing activities within global value chains to avoid head-to-head competition based on cost alone. In this regard, the analysis of the present study is of value because it provides a consistent methodology for the identification of industrial complexes, which is important to understanding the regional trends responsible for Mexico's current position in global trade networks.

DATA AND METHODS

To identify and understand the location of industrial complexes within Mexico, data were compiled from two sources. First, input–output tables from 2003, which contain information about purchases and sales between industries, were obtained from the National Institute of Statistics and Geography in Mexico. These data contain information at the four-digit level of the North American Industrial Classification System (NAICS), which corresponds to roughly 254 industries that describe economic activity in Mexico. The second source of data is employment information from the 2009 Economic Census as reported by the National Institute of Statistics and Geography. This source gathers information about key economic indicators at the municipal level[4] including value added, wages and firms. The employment data collected from this source are available at the four-digit NAICS code level as well.

Before proceeding to a discussion of the analysis, it is important to address the mismatch in the years for which the input–output tables and the employment information are available. Although this mismatch does exist, it is not considered a source of concern for this study. This is because the Mexican economy has remained relatively stagnant over the last decade (Moreno-Brid and Ros, 2009), with negative consequences on productivity and technological innovation. Thus, inter-industry relations are relatively static compared with what they might be in an otherwise more dynamic economy. Second, time lags in input–output data are quite common given the amount of information contained in these tables. Input–output information from the US Bureau of Economic Analysis (BEA) is collected at five-year intervals (BEA, 2014). Thus, aside from pursuing timely and labour-intensive industry surveys annually, time lapses in input–output data are characteristic for data of this nature.

The identification of value chains

The methodology for identifying industrial complexes in this study uses the approach outlined by Feser *et al.* (2005), who use two distinct steps to identify complexes. First, interrelated industries or value chains are identified through a principal component analysis using the national input–output table. Second, the geographic concentration of employment in the identified value chains is analyzed using the Getis and Ord G_i^* statistic (Ord and Getis, 1995). The purpose of these statistics is to capture the association among neighbours for a particular variable of interest, which enables researchers to distinguish locations with a statistically significant concentration of similar values.

The Mexican input–output table, which is a matrix of the purchases and sales between industries, is the starting point for the identification of complexes. The rows of the matrix are selling industries designated by x and the columns of the matrix are purchasing industries designated by y. The values in cells $(_{ij})$ represent the purchases or sales between industries i and j. Thus, the cells of this matrix measure the dependence between industries by the strength of their interactions in terms of (P) purchases and (S) sales (Feser and Bergman, 2000):

$$x_{ij} = \frac{\alpha_{ij}}{P_j},\ x_{ji} = \frac{\alpha_{ji}}{P_i},\ y_{ij} = \frac{\alpha_{ij}}{S_j},\ y_{ji} = \frac{\alpha_{ji}}{S_i} \qquad (1)$$

where α_{ij} is the value of goods and services sold by industry $i(j)$ (row) to industry $j(i)$-(column); x_{ij} is the industry's intermediate purchases from i to j as a proportion of intermediate total purchases; x_{ji} is the industry's intermediate purchases from j to i as a proportion of intermediate total purchases; y_{ij} is the industry's intermediate sales from i to j as a proportion of intermediate total sales; and y_{ji} is the industry's intermediate sales from j to i as a proportion of intermediate total sales

In the next step, four pairwaise correlation coefficients on the industry purchasing and sale vectors are calculated to capture the structural purchase and sales resemblance between two industries, i and j (Feser and Isserman, 2009). This analysis generates four matrices that characterize inter-industry relationships. Combined, these matrices form a symmetrical matrix that contains only the largest coefficient values for each pair of industries. This matrix shows the most important interrelationships between peers of economic industries. After identifying these critical relationships, a factor analysis is used to group industries with similar selling and purchasing patterns (Feser and Bergman, 2000). Factors were selected based on those that contained an eigenvalue higher than 1. This analysis reduced the matrix from 254 to 27 industries. Combined, these factors characterize 92% of the total variation in inter-industry relationships.

The identification of industrial complexes

After identifying related industries in the national input–output table, the national table was regionalized with location quotients computed from employment data to map national inter-industry trends to municipalities in Mexico.[5] The Getis–Ord G_i^* local indicator of

spatial association (ORD and GETIS, 1995) computed with a first-order queen contiguity weights matrix was then used to identify hotspots of inter-industry activity.[6] To control for size effects, which would cause large cities to dominate the results of the spatial analysis, irrespective of their position in the value chain, a procedure originally proposed by FESSER *et al.* (2005) is implemented. This procedure estimates a bivariate model consisting of the regression of municipality value chain employment on total municipality employment. From this model, the residuals are extracted and used in the calculation of the Getis–Ord G_i^* statistic. These residuals are used because they capture excess employment and below-average employment in value chains based upon what might be expected given the overall size of the municipality's employment (FESSER *et al.*, 2005, p. 403).

RESULTS

Identifying value chains

Table 1 contains the five value chains identified based on the input–output approach; these include electronics component manufacturing, automobiles, chemicals, textiles and apparel, and agricultural and processed food. Table 1 also identifies the leading branch industries (NAICS four-digits) that correspond to each of these five value chains.

After identifying these value chains, the employment totals for each were used in the calculation of the G_i^* statistic. A statistically significant result for this statistic was one that represented a z-score greater than or equal to 1.96. The results of these calculations are also presented in Table 1 and represent the number of municipalities with a statistically significant spatial concentration of employment for each of the value chains identified. The G_i^* statistic was computed using several weights matrices to verify the robustness of results, for example, a queen contiguity matrix of order 1, a five k-nearest neighbours matrix, and an inverse distance matrix. While some differences in the number of municipalities across weights matrices are evident, the results of the analysis are generally similar for the queen and the $k-5$ nearest neighbour's weights matrix. When considering the number of municipalities belonging to each spatial complex, the processed food complex contains the most municipalities, followed by textiles and apparel, and then chemicals. The electronics complex contains the smallest number of municipalities.

In order to explore the regional distribution of employment based on the value chains identified, municipalities were classified into five regions, which are displayed in Fig. 1. Table 2 highlights the percentage of employment in each of these five regions broken down by the five value chains identified. Table 2 highlights some differences in the spatial distribution of value chain activity. For example, the Northern region constitutes the largest proportion of employment in three of the five value chains identified including the electronics (86.7%), automotive (60%) and apparel (42%) value chains. Note that the bulk of Mexico's manufactured exports are in the automotive, electronics and textile sectors – the majority of the latter being produced by in-bond firms (*maquiladoras*) (GALLAGHER *et al.*, 2008). Thus, the Northern region is important from an export perspective. The capital region contains the highest concentration of employment in the chemical value chain, while employment in the food-processing value chain is more evenly distributed with the exception of the Southern portion of the country.

The location of industrial complexes in Mexico

For a better visualization of the locations of the value chains identified, Fig. 2 contains maps of the Mexican municipalities with significant G_i^* statistics, as outlined in Table 2. The leading industrial complexes in terms of their percentage of total employment in a particular value chain are denoted with a circle.[7] These maps highlight the location of production in industries in which Mexico has become a global leader. For example, Mexico has become a leader in the production of consumer electronics and appliances, mainly assembling products for export to the US market. According to OECD/World Trade Organization (WTO) trade data, nearly three-quarters of Mexico's total intermediate imports of electronics and equipment are subsequently re-exported, indicating that Mexico still relies heavily on the United States, and increasingly on East Asia, to

Table 1. Value chains identified, 2009

Value chain	Number of complexes (Queen 1 weights matrix)	Main industries associated with the value chain (NAICS, four-digit)
Electronic Components	12	3341, 3342, 3343, 3344, 3351, 3363, 3399, 5171, 5172, 5179, 8112
Automotive	18	3313, 3361, 3363, 3169, 4879, 8111
Chemical	39	2111, 2211, 3252, 3253, 3254, 3255, 3256, 3259
Textile and Apparel	38	1151, 3131, 3132, 3133, 3151, 3152, 3159, 3391, 7115,
Agricultural Products and Processed Foods	43	1111, 1121, 1122, 1123, 1124, 1129, 1151, 2372, 3111, 3112, 3113, 3114, 3115, 3118, 3119, 3121, 3122, 3149, 3253, 3262

Note: NAICS, North American Industrial Classification System.

Fig. 1. *Regional classification of Mexican states*

Table 2. *Regional distribution of the identified industrial complexes*

Region	Electronics	Automobile	Chemical	Apparel	Food Processing
North	86.7	60.0	16.8	42.3	24.2
Capital	1.6	11.0	46.0	22.6	28.5
Central South	3.6	9.1	12.0	2.8	22.0
Central	8.2	19.9	7.9	26.2	20.9
South	0.0	0.0	17.3	6.1	4.4

source higher-value components (PARILLA and BERUBE, 2013).

In the case of the electronics manufacturing value chain, Fig. 2 highlights two complexes on the US–Mexico border. One of these locations represents Tijuana, which leads the country in electronics manufacturing due to the presence of *maquiladora* assembly plants on the border. This cluster is also the primary producer of flat-screen televisions and displays sold in the United States. Similar *maquiladora* clusters focusing on both electronics and appliances are found in other border states around cities like Chihuahua, Juarez, Monterrey and Reynosa. Guadalajara, in Jalisco, is becoming a center of high-tech electronics manufacturing. The largest cluster, in terms of geographic area, is located in Baja California where Mexicali and Enseñada show a significant concentration of employment in this value chain. It is also interesting to note that the industrial complex in Apodaca in the state of Nuevo León borders several municipalities in the state of Coahuila, which appear to be part of a corridor of electronics manufacturing employment involving the municipalities of Saltillo, Ramos Arizpe and the metropolitan area of Monterrey.

Fig. 2 also shows the location of industrial complexes for the automotive value chain. The locations of these complexes are particularly interesting given Mexico's rising share of global automotive production. Since the passage of NAFTA, Mexico has accounted for an increasing share of US motor vehicle imports, particularly in component parts. By 2011, Mexico accounted for 31% of US motor vehicle parts imports, and while the technological capacity of Mexico's auto industry has dramatically improved, it still heavily relies on imported components from the United States (PARILLA and BERUBE, 2013).

The analysis suggests that most of Mexican industrial complexes specialized in the automotive value chain are located around metropolitan areas in close proximity to the US border. These spatial complexes are primarily involved in assembly activities where the leading municipalities are Juarez in the state of Chihuahua, as well as Saltillo and Ramos Arizpe in Coahuila. It must be also noted that significant spatial complexes are located in the region known as '*Bajio*' which arise from the neighbouring states of Guanajuato and Queretaro. These complexes comprise the municipalities of León and Silao, and Queretaro, respectively.

The petrochemical industry is an important sector, especially for manufacturing, because it provides input for more than 40 branches in that sector (ARMENTA, 2008). The geographical distribution of employment in

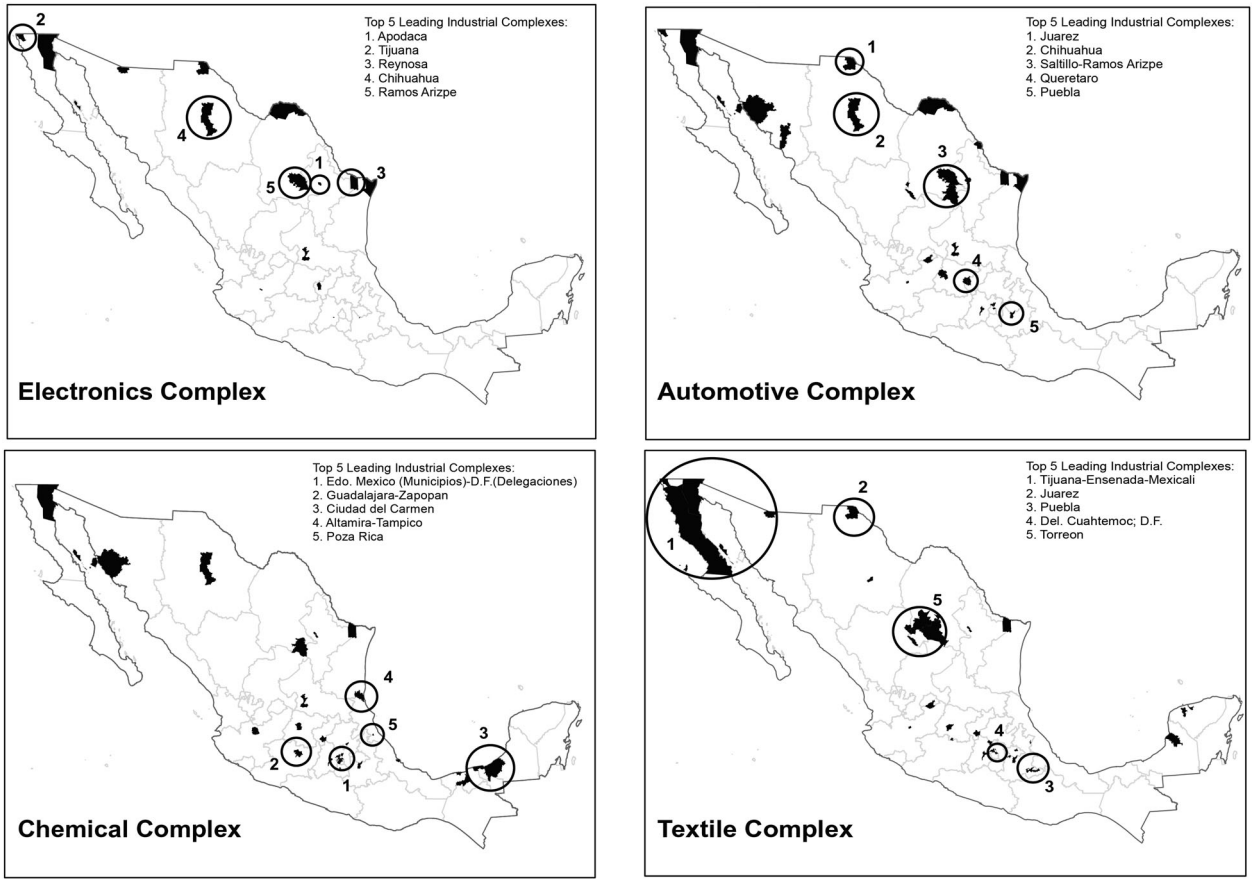

Fig. 2. Spatial distribution of industrial complexes, 2009

the chemical industry value chain tends to be concentrated around Mexico's capital, Distrito Federal, and Estado de México (Fig. 2). Two municipalities belonging to the metropolitan area of Jalisco, Guadalajara and Zapopan, also exhibit significant concentrations of employment. Furthermore, three complexes are identified in states bordering the Gulf of Mexico. These include a complex in Ciudad del Carmen in the state of Campeche, a complex in the southern part of the state of Tamaulipas, which includes the municipalities of Altamira and Tampico, and a complex in the municipalities of Poza Rica in the state of Veracruz. This region has traditionally been an ideal place for the location of chemical and petrochemical companies given the natural resources available in the area. It is worth noting that chemical industries are relatively energy intensive, which implies that the cost of energy will play an important factor in the future development of the industries associated with this value chain and the employment of the municipalities in which they are located.

The textile and apparel value chain is characterized by clear location and operational patterns aimed at the domestic market. Although supply-side issues (e.g., factor inputs) remain very important, market access issues have become a critical factor for recent industrial location patterns. Fig. 2 highlights that the majority of these industrial complexes are not located in large cities, with the exception of the Mexico City metropolitan area. It also displays the location of complexes in the municipalities of Central Mexico, Puebla and the Distrito Federal. Two of the largest complexes are located in the North of Mexico on the Baja peninsula and the middle portion of the country. The first of these complexes is comprised of the municipalities of Tijuana, Enseñada and Mexicali. The second complex is in a region known as 'Comarca Lagunera', which is comprised of the municipalities of Torreón and Gómez Palacio, among others. There are also a few industrial complexes located in the South, particularly in the states of Yucatán and Campeche.

These patterns represent a stark contrast to the distribution of complexes in the processed food value chain which are smaller in size and distributed more or less evenly throughout the country. Leading complexes identified include the Distrito Federal, Guadalajara and Zapopan, San Luis Potosí, Monterrey and Puebla. This distribution may be related to the less intensive nature of technology used in food production by small and medium-sized firms in these sectors. It could also reflect the geography of demand for these products, which is largely of an internal rather than an external nature.

REGIONAL POLICY

The goal of this paper was to identify and analyze the location of industrial complexes in Mexico with the purpose of providing an analytical foundation for the construction of regionally based industrial policies based on the principles of related variety and smart specialization that complement national-level policy efforts to promote investment and stabilize the real exchange rate. This represents a different geographical context for these diversification strategies from prior work with a primarily European emphasis (Boschma and Iammarino, 2009; Asheim *et al.*, 2011). The complexes identified suggest several options for the development of region-specific policies in the future. In the North, public and private investment in spinoff firms on the principle of related variety (Frenken *et al.*, 2007) could be encouraged, with an emphasis on spinoffs in high-technology and knowledge-intensive products and services that have cognitive proximity to current sectors in the region. This element of cognitive proximity is critical to the promotion of related variety and the cultivation of associated knowledge spillovers (Boschma and Iammarino, 2009). These spinoffs could serve as local producers and suppliers, and form much needed backward and forward linkages in the region (Gallagher *et al.*, 2008). Successful spinoffs could help resolve the issue of lagging employment in medium-sized businesses in the country (Bolio *et al.*, 2014), and also form the basis for longer-term strategies that promote regional-branching (Asheim *et al.*, 2011). In addition, mechanisms for facilitating networking among workers, owners of spinoff companies and multinational companies in the region are needed. The role of these entities would be to enable communication between local and multinational firms about supply needs, worker needs and best practices. Such communication is necessary to forming dense networks between producers and suppliers, which are characteristic of competitive regions around the globe. This integration within knowledge networks would foster extra-regional linkages in the form of localized knowledge networks (Boschma and Iammarino, 2009), which would complement current national trade and FDI initiatives.

Regional policies for the central portion of the country (Central and Central South) would need to be designed on the smart specialization principles of embeddedness, relatedness and connectivity (McCann and Ortega-Argilès, 2013; Boschma, 2014). These policies would emphasize diversification based on related variety in the automobile, apparel and food processing sectors (Frenken *et al.*, 2007), and also the connectivity of these industries to their counterparts in complexes located in the North of the country. These intermediate-sized regions, in terms of their share of employment, are the best candidates for smart specialization; much more so than the already competitive Northern portion and lagging Southern portion of the country (McCann and Ortega-Argilès, 2013). Similar to the North, the creation of incentives for public and private investment in spin-offs could foster related variety to build on and diversify these regions' competitive advantage. The chemical value chain, for example, contains employment in electric power generation; here lies an opportunity to create related spinoffs in alternative energy power generation. To enhance regional connectivity, the creation of technical alliances with the North and also local technical guilds is recommended to facilitate extra-regional linkages and knowledge spillovers to help build the knowledge base of local companies and workers. For workers involved in labour-intensive and basic skills-oriented activities, the creation of skills enhancement programmes based on input received from technical alliances and guilds would help expand on the background and skills embedded in the regional labour force.

Finally, in the lagging South, a much different suite of policies might be necessary. While issues related to informality are a countrywide issue (Bolio *et al.*, 2014; The Economist, 2014), informal businesses predominate in this region of the country (Sedatu, 2014), which is associated with negative long-term impacts for productivity and innovation (Bolio *et al.*, 2014). To combat this issue, targeted incentives for small businesses and enforcement of national regulations against informality may help promote formal small and medium-sized business growth. The consolidation of small companies into purchasing consortia may also improve their access to credit, capital and markets (Bolio *et al.*, 2014). Additional funds from the national government to improve education and basic infrastructure in the South may also provide some foundational resources on which empowered businesses can build.

Although not exhaustive, the combined power of these regional efforts would resolve four important issues for Mexico. First, they would foster the creation of spinoff companies in industries in which the country has displayed a regional comparative advantage. Second, sectoral efforts based on related variety could facilitate a better allocation of FDI investment. Third, they will train and attract the necessary workforce for companies. Fourth, they would facilitate coordination between regions to build networks of companies and workers that foster inter-regional and extra-regional linkages. These education efforts would also work within the confines of NAFTA and WTO rules, as well as leverage acceptable financial and fiscal tools to promote innovation and build the technical and educational capacity of the workforce (Moreno-Brid, 2013).

CONCLUSIONS

The implementation of regional efforts alone, however, is insufficient to jumpstarting growth in the Mexican

economy. Instead, these efforts must be supported by national-level initiatives in several areas including infrastructure investments and the stimulation of private investment (Moreno-Brid, 2013). National monetary policies that prevent the appreciation of the real exchange rate are also essential to maintaining the price competitiveness of domestic producers, particularly new producers generated via spinoffs from multinational companies in the North (Moreno-Brid, 2013).

The Mexican economy is at an important crossroads in its developmental trajectory. At this point in time Mexico contains two types of economies: one that is technologically advanced, productive and internationally competitive; and another that is comparatively, traditional, less productive and more isolated (Bolio *et al.*, 2014). This study suggests that the key to Mexico's future lies in fostering regional competitive advantages, as identified in this paper, via policy mechanisms based on related variety and smart specialization, which are better suited for dealing with regional differences in workforce competencies, infrastructure quality and extra-regional linkages than is national industrial policy alone.

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NOTES

1. This definition is based on work from Czamanski and Ablas (1979) and Feser and Bergman (2000).
2. A detailed review of the cluster literature is beyond the scope of this paper. However, see Gordan and McCann (2000) and Martin and Sunley (2003) for thorough reviews of the cluster literature.
3. For thorough historical reviews of Mexican industrial policy, see Moreno-Brid and Ros (2009) and Moreno-Brid (2013).
4. In Mexico, states are divided into municipalities or *municipios*. These are equivalent to counties in the United States.
5. Municipalities are equivalent to counties in US-based studies and NUTS-3 regions in European studies.
6. The results of this analysis were robust to variations in the specification of the spatial weights matrix.
7. A list of the corresponding municipalities that comprise each of these complexes is available from the authors upon request. The map of Agricultural Products and Processed Foods is not included in Fig. 2 due to space limitations, but is available from the authors upon request.

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