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The effect of industrial competition on employment

A Porter's approach to the study of industrial clusters in Mexico

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Abstract

Purpose – This study investigates the existence of Marshall, Jacob and Porter's type of externalities in Mexico. We measure the impact of industrial specialization, competition and diversity on employment growth for the period 2004 to 2008.

Design/methodology/approach – The analysis is based on data from 41 highly dynamic industrial clusters originally obtained by applying Porter's (1998) methodology. We use a cross-section specification estimated via instrumental variables and two-stage least square estimation (2SLS) to control for endogeneity.

Findings – On average, we find that industrial specialization exerts a negative impact on employment growth within states and within clusters, indicating that traded industries in Mexico carry very little innovation, operate in early stages of the life cycle, face high costs of employment reassignation or exhibit low adaptability. A negative impact of specialization on employment conforms with Jacobs (1969) type of externalities and confirms what other studies have found in France (Combes, 2000), Korea (Lee *et al.*, 2005) and the USA (Delgado *et al.*, 2014). The authors also find that competition generates more employment.

Research limitations/implications – Industrial data at the sub-branch level were obtained from the Economic Census (EC) of the National Institute of Geography and Statistics (INEGI). The EC information for 2004 was still not fully compatible with the North America Industry Classification System (NAICS), with 262 of the 309 data at the fourth-digit level aligned to the USA. In addition, industrial information from the EC is recorded every four years, which prevents this study to use panel data techniques and it makes it impossible to use time series methods.

Practical implications – Policymakers can clearly identify competition forces having a significant impact on employment growth. This can orient policymakers to implement measures to encourage the development of some of these clusters, as well as to identify some of the sources that drive specialization, competition and diversity.

Originality/value – This paper contributes to the debate on the existence of Marshallian (MAR), Jacobian and Porter externalities. This is the first study using the definition of traded clusters in Mexico, which allows the authors to identify how specialization, competition and diversity forces drive the dynamics of regional employment growth.

Keywords Cluster, J21, L26, L52, R11, R30

Paper type Research paper

1. Introduction

Several authors find that specialization, competition and diversity promote economic growth and development. The final effect of these forces on employment is actually inconclusive and depends on the economic structure of the given region. Combes (2000) finds that specialization exerts a negative impact on employment growth in French regions at the industrial sector level. Galliano *et al.* (2015) find a positive effect of specialization on innovation and innovation intensity in French industries. In Mexico, Mendoza and Pérez

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(2007) find a negative impact of industry specialization on employment growth. In contrast, Herderson *et al.* (1995) report a positive impact of high-tech manufacturing industry specialization on urban growth in the USA (USA). Delgado *et al.* (2014) confirm the negative association in the USA at the industry level, but also reveal a positive association at the cluster level (aggregating related industries). Delgado *et al.* interpret this change to positive association at the cluster level as an indication of greater industrial maturity.

Glaeser *et al.* (1992) find that industrial concentration at sector level affects the growth of local economies. In Mexico, Baylist *et al.* (2012) observed that concentration does not explain economic development at municipal level – even after the North American Free Trade Agreement (NAFTA) took effect. Whenever international trade intensifies, industrial concentration starts to diminish (Krugman and Livas, 1992). Mendoza and Pérez (2007) describe how industrial agglomeration externalities affect employment growth in Mexico, from 1988 to 1997.

Industrial specialization acts as a knowledge force spilling over groups of industries, while diversity reflects the transmission of information between clusters – defined by Porter (1998, 2003) as groups of closely related complementary industries operating in specific geographic zones. Diversity creates employment and many authors regard it as a force of innovation (Jacobs, 1969; Herderson *et al.*, 1995). Forni and Paba (2002) also find positive impacts of diversification in early stages of innovation. However, while studying French industries, Galliano *et al.* (2015) find that "Jacobian" diversity brings out a negative effect on innovation intensity confined to one location. Diversity has also been related to economic resilience and adaptability in the face of external shocks as in Kahl and Hundt (2015).

This paper contributes to the debate on the existence of Marshallian (MAR), Jacobian or Porter externalities through the study of specialization, competition and industrial diversity by clusters in the 32 states in Mexico, from 2004 to 2008. For the first time in the literature regarding industrial behavior in Mexico, we distinguish the impact of concentration at the industry and cluster level as classified by Porter (1998, 2003). We construct a database fully consistent and comparable with US industries, using the methodology of the Cluster Mapping Project (CMP) of the Institute for Competitiveness and Strategy (ICS) in the University of Harvard. The database contains information of industries at the six-digit level under the North American Industry Classification System (NAICS).

In particular, we analyze employment growth in Mexico from 2004 to 2008 by industrial cluster for each state, in relation to the forces of specialization, competition and diversity. We test the magnitude and direction of these forces on employment growth. We find a strong co-linearity between concentration and specialization, which leads us to define an adjusted specialization variable. The potential endogeneity from specialization is addressed using instrumental variables and two-stage least squares (2SLS). We allow for temporal and regional fixed effects to account for the differential behavior of industrial clusters in each state and year in the sample. In contrast with other studies, we focus on highly dynamic sectors in Mexico known as traded clusters: groups of highly specialized, efficient and related industries with strong commercial links overseas.

This study allows us to identify important cluster features that have been previously reported in Mexico such as knowledge spillovers (Mendoza, 2007; Chiquiar, 2005; Baylist *et al.*, 2012). We test whether Jacob's type of externalities is present in the industrial clusters defined by Porter (1998, 2003) in Mexico. We reveal whether specialization has a negative effect on employment growth, but also if competition and diversity encourage employment growth. The presence of Jacob's externalities will allow us to characterize some features of industrial clusters such as their speed of adaptability to shocks, knowledge spillovers, innovation, industrial verticality, among other features.

This paper is divided as follows: in Section 2, we make a brief literature review to support the study of specialization, concentration and industrial diversity. In Section 3, we describe Porter's (1998, 2003) methodology and the database construction process. We also undertake a descriptive analysis of industrial competitiveness in Mexico. In Section 4, we present the econometric model, explain the estimation methodology and describe the results. In the last section, we present the conclusions.

2. Literature review

Several authors have meaningfully contributed to the study of agglomeration, industrial specialization, as well as to the impact of these forces on economic performance – see Marshall (1920), Arrow (1962), Romer (1986), Porter (1990), Krugman (1991a) and Ellison and Glaeser (1997). Marshall argued that the increased efficiency of the production factors, the cost optimization, as well as the increase in the capability to innovate and lower transactions costs constitute the benefits of industrial agglomeration in the regions. Weber (1929) explained that industries tend to establish closely with the aim of reducing transport costs and in general, as a strategy to minimize production costs.

These seminal contributions were recently reignited by the introduction of the concepts of agglomeration forces by Krugman (1992). Krugman found that industrial agglomeration lowers production costs by:

- a joint labor market;
- intermediate inputs – industrial concentration leads to a greater availability of specialized local suppliers; and
- technological osmosis – more specialized knowledge and information to be to be shared.

Krugman (1991a, 1991b) relates competitive markets and agglomeration and describes two forces: centripetal, when the market structure favors industrial agglomeration versus centrifugal, when competitive conditions dissuade industrial agglomeration. Some other authors incorporate the role of local demand, institutions, the structure of businesses and also the influence of social networks in a wider sense (Delgado *et al.*, 2014).

Agglomeration and spatial concentration have been widely studied in the literature as a source of knowledge and information spillovers. Some authors note that the final effect on economic performance, e.g. observing employment growth, depends on the capacity of geographic units to take advantage of these forces, to facilitate information spillovers and to exploit technology transfers – see Mendoza *et al.* (2007) and De Lucio *et al.* (2002).

However, the ultimate effect of the forces localization, agglomeration and concentration on economic growth remains unresolved – e.g. Fu and Hong (2011) report mixed evidence. Some authors suggest that the relationship between industrial forces and the prospect of regional economic growth is subtle – see Glaeser *et al.* (1992). For instance, the impact of concentration on growth depends on geographical conditions, natural endowment and the competition structure in each region. Greater industrial concentration could lead to diminishing marginal returns in regions with scarce natural resources. On the contrary, centripetal forces may boost employment in regions with abundant resources due to increasing returns to scale – see Delgado *et al.* (2014). Costs and competitive advantages of geographically related industries may also condition the overall effect of concentration on employment and on economic performance, overall.

Specialization is perhaps one of the most studied forces affecting the development of industrial clusters. From the seminal contributions of Marshall (1890) to the latter studies of Glaeser *et al.* (1992) and Nefke *et al.* (2011), we know that specialization correlates with knowledge creation and diffusion. Specialization and knowledge spillovers should blossom within clusters of closely related traded industries. Interestingly, Porter (1990) observed that knowledge spillovers occur more frequently on vertically integrated industries. Knowledge transmission should evolve within firms and industries of the same branch. Some other authors have found a negative influence of foreign direct investment on specialization and a positive effect on diversification (Wang and Wu, 2016). Other authors have related specialization to innovation in emerging countries, such as the Portuguese regions (Ferreira *et al.*, 2012).

Nonetheless, the process of knowledge transmission and spillovers generated by specialization is not fully understood yet. Galliano *et al.* (2015) explain that knowledge externalities only occur between firms of the same industry and therefore that they can only be facilitated by the geographical concentration of firms that belong to similar industries. Krugman (1991a, 1991b) notes that these features (i.e. knowledge and information spillovers) are difficult to measure empirically. Specialization can reveal the presence of knowledge transmission, as well as the degree of interaction among industries. This concept of specialization approaches more to the ideas of Glaeser *et al.* (1992) and is known in the literature as Marshall externalities or MAR, an abbreviation including the works by Arrow (1962) and Romer (1986), strongly linked to the works on competition by Porter (1990) – see Beaudry and Schiffauerova (2009).

The evidence on the direction of the impact of specialization on economic growth is also mixed. Studies finding a positive impact argue that this is a result of the continuous search of industries for bigger and more specialized cities, with innovative and diversified environments (Duranton and Puga, 2000). Similarly, Cainelli *et al.* (2001) suggest that this positive association is observed in industries located in prosperous regions, with solid and innovative technological basis. Porter (2003) points out that specialization positively affects the growth of wages. Other studies find a negative relationship between specialization and employment growth, resulting from rigidities and slow adaptation of regions to economic shocks, e.g. financial crisis (Duranton and Puga, 2000). Boschman *et al.* (2005) note the inverse relationship between the stage of the firm and the industrial cycle: early stages of industrial development are characterized by highly diversified Jacobian externalities, while later stages of maturity show a negative impact of specialization on growth. Glaeser *et al.* (1992) explain that economic contraction due to greater specialization may be due to the abandonment of traditional activities. Combes (2000) suggests that the negative impact can be due to pro-cyclical behaviors: regional industrial employment grows in periods of expansion, but can stop or even fall during recessions because of rigidities in the markets.

We hypothesize that given the economic conditions in Mexico, specialization exerts a negative effect on employment growth. That is, we expect that specialization conforms with Jacobs (1969) type of externalities, where industries are subject to little innovation, operate in early stages of the life cycle (are emerging industries), are rigid and show low adaptability to economic shocks.

Porter (1990, 1998) proposes a novel approach to the study of industrial clusters in which employment growth is associated with industrial agglomeration and regional competition – see Delgado *et al.* (2010, 2014). In this literature, complementary activities increase the availability of inputs and generate positive externalities, incentivizing entrepreneurs toward more innovation and growth (Delgado *et al.*, 2014). Recent studies have applied the cluster concept to examine these competition forces (Liu *et al.*, 2014; Zhou and Ming, 2014) and to examine the resilience of regional employment to economic downturns (Delgado *et al.*, 2015), or to measure external shocks, such as the global financial crisis as in Kahl and Hundt (2015). Other applications have examined the impact of clusters on regional economic performance in specific sectors such as the maritime cluster (Stavroulakis and Papadimitriou, 2016) or Resbeut and Gugler (2016) in the precision goods sector of Switzerland. Huo (2014) examines the country-level factors explaining competitiveness in emerging markets industries. In Mexico, some work has been done investigating IT clusters and the role of institutional arrangements (Gutierrez-Martínez *et al.*, 2015).

We conjecture that competition has a positive effect on employment growth, consistent with Porter (1990, 1998) and Storper (1995a, 1995b). That is, we expect that competition encourages innovation and hence job creation. In turn, as noted by Jacobs (1969), diversification, e.g. the local variety of industries, facilitates access to qualified workforce. Knowledge spillovers are enhanced by diversified industrial environments in close proximity due to more opportunities to imitate, share and recombine ideas and practices across industries (Beaudry and Schiffauerova, 2009). Hence, in line with Jacobs' model, we hypothesize that diverse traded industries generate the conditions for innovation and employment growth.

In summary, following the literature on MAR economies, in this paper, we aim to formally test the hypothesis above and investigate the role of cluster specialization, competition and diversification on employment growth in Mexico, from 2004 to 2008. In general, we conjecture that these competition forces positively affected regional economic growth during that period, favoring the formation of industrial clusters in this country.

3. Traded clusters in Mexico

We obtain industrial data from two rounds of the Economic Census (EC) in 2004 and 2008, published by the National Institute for Geography and Statistics (INEGI) in Mexico. The data conform almost in general with the North American Industry Classification System (NAICS) that divides the total industrial activity in 20 sectors (the more general level), 94 subsectors, 304 branches, 617 sub-branches and 1,049 activity classes.

The remaining differences in the classification of industries in both countries were arranged by aligning codes, levels of aggregation, mnemonics, etc. Some industries in Mexico use six digits (288 industrial codes), while in the USA, these same industries are aggregated at fewer digits. For these cases, we collapse the last digits in the Mexican database and changed the last digit to 0, 1 or 9, in correspondence with the US database. Similarly, in some instances (133 cases), US codes have relatively greater disaggregation; we aggregate these and add 1 or 9 as the last digit of the code. Some other classifications in Mexico showed different codes than those in the USA, but in fact, they really belonged to the same industry (28 cases). We aligned Mexican codes to US codes. Additionally, there were 36 cases in which the description was identical in both databases but were officially labeled with a different code; we assigned the US code to the Mexican industries. Lastly, some industrial codes are exclusive for Mexico; these are aligned to the closest US equivalent (seven cases). All these are minor adjustments that have no impact on the final identification of clusters, but ensure a consistent comparison between Mexico and US industries using Porter's cluster characterization[1].

After matching the databases, we adopt Porter's clusters mapping. Porter (1998, 2003) defines clusters as groups of closely related and complementary industries operating in a specific region. He distinguishes three type of industries:

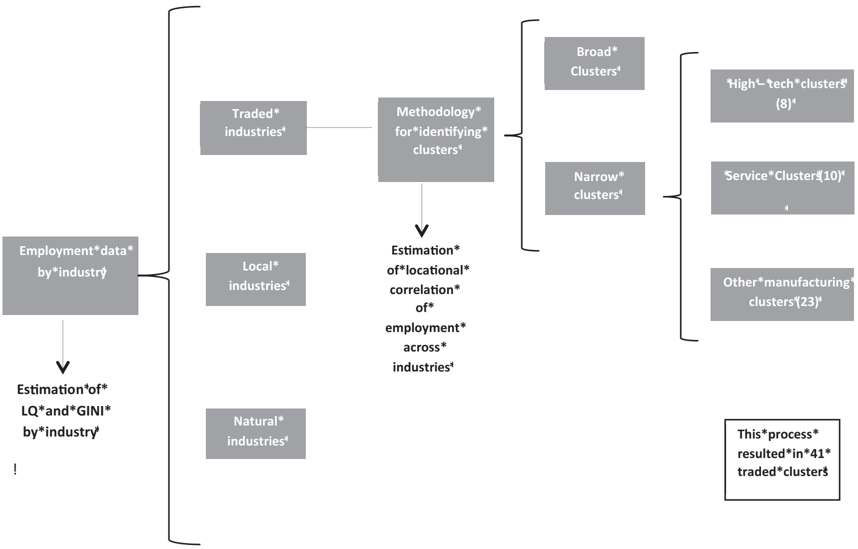
(1) local industries, those that provide primary goods and services in the local market, not competing with other regions or countries (e.g. such as health, school, construction);

(2) natural resource-driven industries, generally established in areas with abundant natural resources such as mining; and

(3) traded industries, whose location depends more on competiveness than geographical considerations, that can sell products in regions within the country or with other countries.

Examples of this last type of industries are the automotive industry, aircraft engineering and the film industry. Figure 1 summarizes Porter's methodology for the identification of clusters using correlation, location and industry distribution criteria.

In this study, we focus on closely related traded industries with the purpose of analyzing regional industrial dynamics in Mexico. This approach allows us to verify the impact of MAR externalities (specialization, concentration and diversity) on economic regional growth[2]. Porter's method provides 41 traded clusters, eight out of which are classified as high-technology clusters, 10 as service clusters and 23 as other manufacturing industries clusters. Each cluster contains on average 28 industries. In 2004, traded clusters in Mexico included 494 industries that generated 6.5 million jobs all together, while in 2008, traded clusters added up to 500 industries, generating a total of 7.3 million jobs[3]. High-tech clusters have a low weight on the economic performance in each country, both in relation to the number of firms and also in relation to capacity to generate jobs. While the number of industries in the services cluster is greater for Mexico (210 vs 160 in the USA), the employment generated by these clusters is much lower (2.5 million jobs in Mexico vs 20.4 million jobs in the USA). This means that, in Mexico, the cluster of services generates 65.7 thousand jobs per industry, while in the USA, each industry generates 127.5 thousand jobs



Notes: Location Quotient (LQ) measures the national share in cluster employment relative to its overall share of NAFTA employment. A LQ > 1 indicates an above average employment share in a cluster. In this case, the GINI index measures the inequality of the number of employments by industry

Source: Own hierarquization based on Porter (2003)

Figure 1. Porter's traded clusters

per industry on average. A similar pattern is shown by other manufacturing industry clusters, on average each generate about 13.8 thousand jobs, while in the USA, this cluster generates 26.4 thousand jobs per industry.

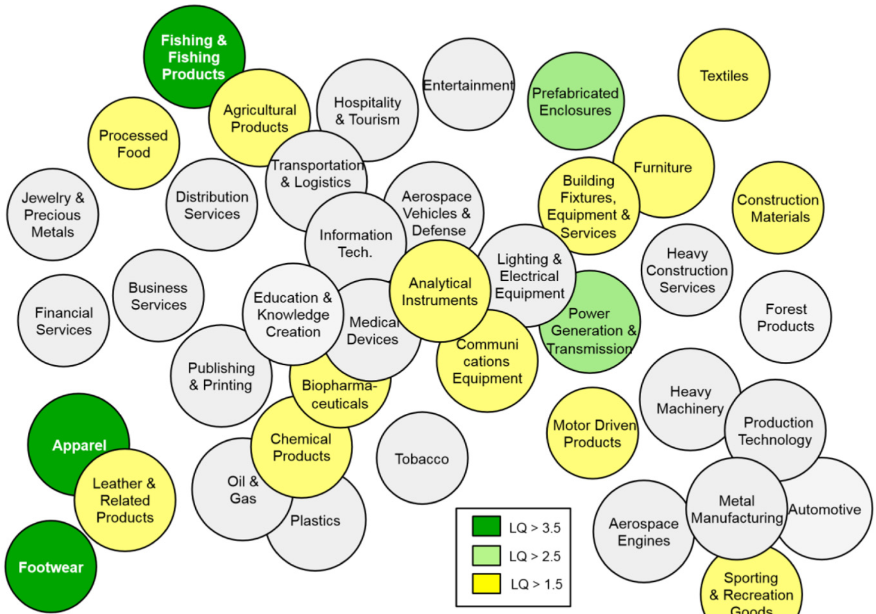
Figure 2 below shows Porter's portfolio of traded clusters. The location coefficient of employment (LQ) emphasizes the economic importance of traded clusters in Mexico. LQ measures the share of employment generated by each cluster in the country with respect to the overall employment of the NAFTA countries. LQs greater than 3.5 (dark circles) reveal the clusters with the greatest share of employment, among them apparel, footwear, fishing and hunting products industries. These are followed by industries in the range of $2.5 < LQ < 3.5$ (in dark gray) such as power generation and transmission and prefabricated enclosures. Most of the traded clusters in Mexico lay in the range $1.5 < LQ < 2.5$.

Figure 3 shows traded cluster performance by state. There are in general three types of groups:

(1) states with a lower relative share of employment creation with LQ <1 (e.g. Durango, Coahuila, Distrito Federal, Chihuahua, Yucatán, Tamaulipas, Aguascalientes);

(2) states with a greater relative share with respect to the national level, with LQ > 1.1 (e.g. Chiapas, San Luis Potosí, Querétaro, Oaxaca, Colima, Quintana Roo and Baja California Sur); and

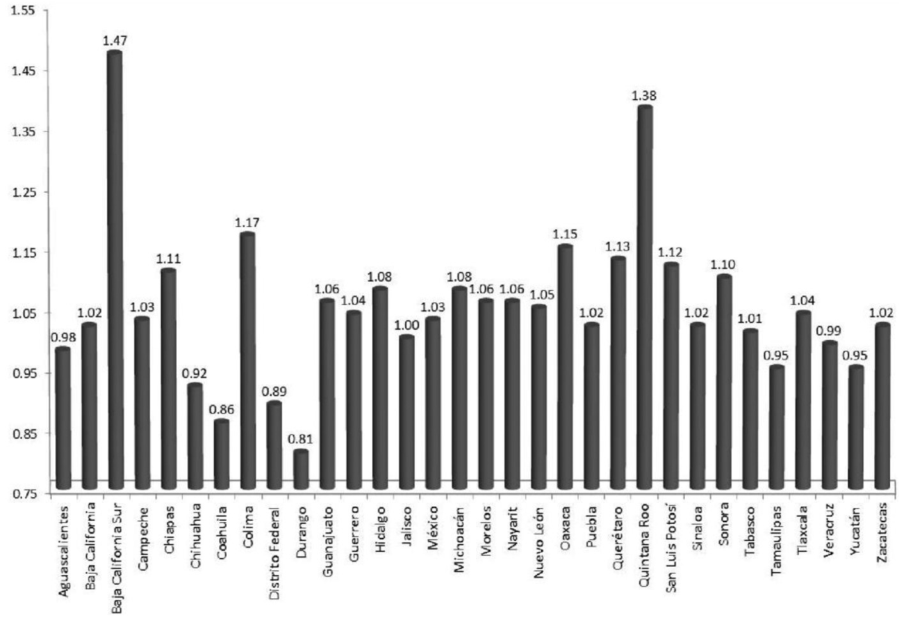
(3) states with employment creation similar to the national level (e.g. Jalisco, Sinaloa, Puebla, Nuevo León and Guanajuato), with $0.90 < LQ < 1.10$.



LQ, or Location Quotient, measures the National share in cluster employment relative to its overall share of NAFTA employment. An LQ > 1 indicates an above average employment share in a cluster.

Figure 2.
Portfolio of traded clusters and degree of specialization

Sources: Own calculations based on Prof Michael E. Porter, Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School; Richard Bryden, Project Director; contributions by CIIE-UPAEP and Prof Niels Ketelhohn



Source: Own calculations based on EC and Mexico CMP, ICS, Universidad de Harvard

Figure 3.
Relative importance of employment by state 2004-2008

This plot illustrates that employment generation patterns are heterogeneous across different states in Mexico. Some authors have already reported that employment growth of northern states in Mexico is greater than other regions (Calderón and Tykhonenko, 2006; Chiquiar, 2008).

Porter (2003) has explained that industrial cluster formation by region allows industries to reduce transaction costs, accelerate learning and knowledge spillovers. When this industrial agglomeration is located in a competitive environment, there are positive effects on economic growth. We formally test in the following section whether industrial agglomeration, specialization and diversity of traded clusters by region in Mexico have a positive impact on employment growth.

4. Employment growth and the forces of competition

The literature suggests that all three specialization, agglomeration and diversity forces can jointly explain employment growth in an economy. Clusters grow in competitive environments, facilitating positive externalities such as knowledge transmission and spillovers. On the contrary, industries experience diminishing returns to scale and employment loses when markets concentrate or operate with scarce resources. We now define the main variables of the analysis and test these conjectures for the case of Mexico.

4.1 Modeling employment growth

We use an adjusted measure of regional growth to explore the association between employment and the forces of regional specialization, concentration and diversity in Mexico for the period 2004-2008. We follow closely the literature on regional industrial development and localization in the line of Combes (2000), Higgins *et al.* (2006) and Delgado *et al.* (2014). We particularly aim to measure the relative importance of these forces at an industrial level on employment growth by cluster and by state during the period of analysis using the following specification:

$$y_{sc,t} = \beta_0 + \beta_1 S_{sc,t-1} + \beta_2 C_{sc,t-1} + \beta_3 D_{sc,t-1} + \alpha_s + \alpha_c + \varepsilon_{sc,t} \tag{1}$$

Equation (1) adopts a version of the models suggested by Combes (2000) and Delgado *et al.* (2014), where the dependent variable y_{sc} represents employment growth in cluster c of state s at time t ($L_{sc,t}$), adjusted for national employment growth in the specific cluster c (L_c) for the period 2004-2008, i.e.

$$y_{sc,t} = log\left(\frac{L_{sc2008}}{L_{sc2004}} \middle/ \frac{L_{c2008}}{L_{c2004}}\right) \tag{2}$$

Additionally, we use a set of regressors measured in 2004 (*t–1*) to capture the effect of agglomeration forces on employment growth during the whole period. The variables are transformed into logarithms; hence, each parameter represents an elasticity.

Similar to Combes (2000), the variable S_{sc}, represents specialization for cluster c in state s, adjusted for the pattern of specialization at the national level in time *t–1*. The specialization measure is:

$$S_{sc,t-1} = log\left(\frac{L_{sc2004}}{L_{s2004}} \middle/ \frac{L_{c2004}}{L_{2004}}\right) \tag{3}$$

This specialization variable measures Marshallian externalities expressed as the relative importance of cluster c in state s at time *t–1*, with respect to the contribution of this cluster at the national level. Notice that when industrial cluster concentration in a given state (numerator) is greater than the concentration of the same cluster at the national level (denominator), S_{sc} will be positive, while when it is lower, S_{sc} will be negative: a value greater than unity indicates higher relative specialization of the cluster in the state. A significant estimate of β_1 will reveal knowledge transmission within the industry. The sign of β_1 represents the direction of the final impact of specialization on employment growth and can be either positive or negative; in the end, the effect depends on the industrial patterns and forces of competition operating in each region or cluster.

In addition to specialization, the environment of competition also affects employment growth. This is more characteristic of Jacobian and Porter effects. To capture these effects, we use a version of the Herfindahl index previously used by Combes (2000), which measures the relative importance of industrial concentration in a given regional cluster, with respect to the national level in *t–1*. That is:

$$C_{sc,t-1} = \frac{\sum_i (L_{ci2004}/L_{c2004})^2}{\sum_{i \in s} (L_{sci2004}/L_{sc2004})^2} \tag{4}$$

Whenever industrial cluster concentration in a given state is lower (greater) than the concentration at the national level, C_{sc} will be greater (lower) than unity. We expect that less concentrated cluster environments increase employment growth, $\beta_2 > 0$ in equation (1).

We also measure industrial diversity. This index explores concentration without considering the specific share on employment by industries in cluster c, that is, we focus on the a priori cluster environment. We remove the effect of cluster c in the concentration of the market and measure how concentrated the environment is without industries belonging to cluster c. The variable div_{sc} is constructed as follows:

$$D_{sc} = \frac{\sum_{c'=1;c'=c}^{c} [L_{c'2004}/(L_{2004} - L_{c2004})]^2}{\sum_{c'=1;c'=c}^{c} [L_{sc'2004}/(L_{c2004} - L_{sc2004})]^2} \quad (5)$$

A high level of D_{sc} describes a very diverse cluster environment in the given state in relation to the national level. In model (1), a positive sign of β_3 indicates that more diversity leads to greater employment, whereas a negative coefficient indicates employment decrease as a result of greater diversity. The response of employment to more diverse environments, however, will depend, in general, on the specific economic conditions of a given state.

In addition to all these competition variables, it is essential to control for the specific geographic and economic conditions that affect employment growth. In this cross-sectional study, we then allow for fixed effects to capture the differential impact of specific factors affecting states and cluster dynamics on employment growth, i.e. α_e and α_c, respectively.

4.2 Estimation strategy

We estimate three versions of model (1):

(1) The first version controls for the possibility that employment growth is both different by region (state) and by cluster. That is, we control for the simultaneous effect of geographic and economic conditions[4].

(2) The second version controls for fixed effects only at the regional level.

(3) The third version controls for fixed effects only at the industrial cluster level. As a final exercise, we estimate model (1) for each state and cluster individually.

The control of bias from unobserved factors (region and cluster) allows us to focus on the specific effect of externalities (specialization, concentration and industrial diversity) on employment growth. We measure these externalities at the beginning of the period to avoid further impacts of employment growth on externalities. In spite of this, endogeneity may still arise from the variable of specialization. Storper (2010) argues that agglomeration of a highly specialized industry can indeed generate greater employment, but at the same time, greater labor basis can facilitate specialization via selection, skills, migration, among other channels. This possible association between specialization and the error term has been accounted for by Chang *et al.* (2009) and Areski *et al.* (2009) in a study on the effects of specialization over tourism growth.

We use an instrumental variable approach and 2SLS. We use the relative size of the cluster as an instrument (S_{ec}) of specialization[5]. In particular, the size variable measures per capita employment by cluster in a given state, relative to the national level, i.e.

$$size_{sc} = log\left(\frac{L_{sc2004}}{n_{sc2004}} \middle/ \frac{L_{c2004}}{n_{c2004}}\right)$$

The partial correlation coefficient between the size of the clusters and specialization is 0.5498 (see Table AI), which in addition to the endogeneity tests, suggests that we can maintain efficiency if size is used as an instrument[6].

4.3 Estimation results

We adopt Porter's (1998, 2003) methodology to the identification of industrial clusters. This allows us to compare our study with research carried out in the USA, e.g. Delgado *et al.* (2014, 2015). It also provides a highly influential and widely accepted framework for empirical analysis, always in the center of the debate on competition – see Huggins and Izushi (2011).

We are interested in understanding the behavior of traded clusters, as they are formed by highly dynamic industries that chose a location based on competitiveness on top of geographical conditions. Porter identifies 41 traded clusters, which we adopt to analyze employment growth in the 32 states in Mexico, from 2004 to 2008. In total, we use 12,137 observations corresponding to positive employment from 2004 to 2008 in 32 Mexican states[7].

Table I shows the aggregate estimations based on model (1), considering (a) fixed effects by state and cluster simultaneously, (b) fixed effects by state and (c) fixed effects by cluster. Cases (a) and (c) are estimated using instrumental variables and 2SLS. Durbin-Wu-Hausman tests maintain the exogeneity hypothesis in the estimation by state (column b), which uses ordinary least squares without affecting the implications.

4.3.1 Specialization. We find a significant impact of specialization on employment growth, which at first instance, supports the idea that regional economies based in proximity of related industries explain industrial employment growth in Mexico. The specialization coefficient measured by β_1 in our estimations is negative, i.e. more specialization in the beginning of the period leads to lower employment growth by industries in Mexico. Glaeser *et al.* (1992) point out that employment contraction after an increase of specialization is the result of very little innovation of traditional industries. This suggests that traditional industries could promote employment growth by adopting technology and innovating.

According to Lee *et al.* (2005) and Beaudry and Schiffauerova (2009), the estimated negative direction of the parameter of specialization contradicts the proposal of MarshallArrow-Romer (MAR) and also of Porter's model, where knowledge transmission should occur between industries within the same cluster. Our results imply that relationships

	Model (1) with fixed effects		
Statistic	State and cluster (a)	State[e] (b)	Cluster (c)
Constant	0.1143 (0.020)[a]	0.843 (0.040)	0.055 (0.007)
Specialization	−0.039*** (0.003)	−0.033*** (0.002)	−0.043*** (0.003)
Competition	0.002*** (0.0004)	0.002*** (0.0002)	0.001*** (0.0004)
Diversity	−0.006*** (0.001)	−0.003*** (0.001)	−0.002*** (0.0001)
R^2 adjusted	0.234	0.090	0.189
χ^{2b}	10.326***	1.018	38.615***
F^c	11.775***	0.988	44.633***
n^d	12,137	12,137	12,137

Notes: ***, ** and *Significant at 1, 5 and 10%, respectively; [a]robust standard errors; [b]endogeneity tests; [c]test of exogeneity for specialization; [d]ordinary least squares (OLS) estimations due to rejection of exogeneity; [e]number of observations

Table I. Specialization, competition, diversity and employment in Mexico, 2004-2008. Overall regressions between industries within traded industries are few and that, knowledge transmission, innovation and learning between them is scarce, leading to low employment growth.

The negative impact of specialization on economic performance points to industries in the initial stage of their life cycle (Beaudry and Schiffauerova, 2009). The association and magnitude of specialization found in Mexico conform with Jacobs (1969) type of externalities and the empirical findings of Combes (2000) at the industrial sector level in France. The results are also consistent with the findings by Lee *et al.* (2005) in the Korean manufacturing industry and Delgado *et al.*'s (2014) study of industrial clusters in the USA. All in all, it is not rare to find a negative relation between specialization and employment growth. The result reveals some or all of these features in the Mexican industry: premature industries and also a high level of rigidity, overcrowding, costs of employment reassignation and lower degrees of industrial adaptability – see Combes (2000) and Cingano and Schivardi (2004)[8].

4.3.1.1 Specialization and employment by state. Table II shows the estimations of model (1) for every state. Here, the interest is to see the patterns of competition within specific geographic units. The results are consistent with the global estimation above, i.e. specialization exerts a negative impact on employment, in some states with greater intensity than in others. Figure 1 in the Appendix shows statistically significant estimations for β_1 in the range of $[-0.293, 0.015]$ by region. The states of Aguascalientes, Zacatecas, Sonora and Tlaxcala stand out by the size of the negative coefficients. The negative coefficient of specialization may also reveal scarce innovation, limited transmission of knowledge and low information spillovers. On the other side, the states of Baja California, Nayarit, Chihuahua and Estado de Mexico (among others) show lower negative coefficients. We conjecture that specialization in these states generates lower rates of employment as a result of low flexibility, few adaptability and market saturation. Just few cases show a positive specialization parameter such as Distrito Federal and Coahuila, where there is a greater growth of employment at higher rates of specialization.

4.3.1.2 Specialization and employment by industrial cluster. Table III shows the estimation results of the specialization parameter for each traded cluster in Mexico. We look into the competition forces inside each cluster independently of location. In general, for each traded cluster, we also observe a negative impact of specialization on employment growth (also see Figure A2 in the Appendix). The results at the cluster level present a range similar to the estimations by state, with values from 0.0114 in the business services cluster, to -0.391 in the power generation and transmission cluster (see Figures A1 and A2 in the Appendix). The negative impact of specialization on employment tends to be higher when measured by clusters than when measured by states. Out of total 32 clusters, 11 show parameters of specialization with sizes lower than 0.100, similar to the global estimations in Table I, which is a considerable negative impact on employment. Another portion of clusters (15 out of 32) has low coefficients between -0.091 and -0.018 and only six clusters have a positive value of specialization.

Clusters with the highest negative values are power generation and transmission (0.391), information technology (-0.326), communication equipment (-0.276), heavy construction services (-0.274), among many others. For all negative coefficients and specially for these last cases, the results fit Jacobs' type of externalities. According to this, traded industries in these clusters operate in premature stages of development.

Clusters registering a positive effect of specialization on employment are business services (0.114), processed foods (0.091), petroleum and gas products (0.083), construction machinery (0.059), transportation and logistics (0.021) and metal manufacturing (0.018). The cluster of business services is the only cluster with a positive coefficient greater than 0.114.

State	Specialization[a]	Competition[b]	Diversity[c]	Constant	n
Northern frontier Baja California[d]	−0.012***	−0.007***	0.021*	−0.099	425
Coahuila[d]	0.015**	0.001***	0.087***	−0.482***	413
Chihuahua[d]	−0.025***	−0.004**	0.020***	−0.203***	409
Nuevo León[d]	−0.074***	0.003***	0.014***	−0.131***	464
Sonora	−0.144***	−0.004	0.073*	−0.010	411
Tamaulipas[d]	0.019	−0.009**	0.026	−0.216**	408
Center–North Aguascalientes	−0.293**	0.005***	−1.931**	1.312**	367
Baja California Sur	0.001	0.009***	1.381	0.009	253
Durango	−0.129***	−0.002*	−0.179	0.221**	349
Nayarit	−0.022***	0.005**	0.245	0.040	294
San Luis Potosí	−0.063***	0.002**	−0.074	0.151***	419
Sinaloa	−0.034***	0.004*	−0.063	0.138	372
Zacatecas[d]	−0.229***	0.008***	−3.203***	0.657***	289
Center–South Colima	−0.100***	0.003	−2.125	0.345***	293
Guanajuato	−0.002	−0.001	0.043***	−0.259***	441
Hidalgo	−0.069***	−0.001	0.499***	−0.132**	379
Jalisco	−0.071***	0.003	−0.011***	0.237**	473
Michoacán	−0.107***	0.003***	−0.062	0.243***	408
Morelos	−0.123***	0.010***	−0.388***	0.294***	362
Pueblad	−0.046***	0.000	0.000	0.093**	440
Querétaro	−0.067***	0.004***	0.024	0.065	401
Tlaxcala	−0.143***	0.009***	−2.002***	0.703***	320
Veracruz	−0.052***	0.003***	0.053***	−0.155***	447
Mexico City Distrito Federal[d]	0.008***	−0.001***	0.000	−0.079**	486
México[d]	−0.029***	−0.001***	−0.005***	0.175***	467
South Campeche[d]	0.007	−0.009**	3.627***	−0.779***	288
Chiapas[d]	−0.066***	0.002	0.234***	0.019	357
Guerrero[d]	0.005	−0.003*	0.467***	−0.268***	332
Oaxacad	−0.008	−0.003**	0.166**	−0.013	350
Quintana Roo	−0.048***	−0.009***	−0.680***	0.516***	300
Tabasco[d]	−0.010	−0.001	0.439***	−0.142**	318
Yucatán[d]	−0.019	0.003	0.062	−0.060	402

Notes: ***, ** and *Significance at 1, 5 and 10% levels, respectively; [a]specialization elasticity; [b]competition elasticity; [c]diversification elasticity; [d]In these clusters, the Durbin-Wu-Hausman does not reject the exogeneity of specialization; hence, estimations with OLS are presented. The rest of the cases use size variable as a specialization instrument. In this case, the sum of squared residuals (SSR) is greater than the total sum of squares (TSS), which results in negative R^2, an occasional result of instrumental variables method. RSS is obtained from regression (1) with original variables and TSS is obtained with the regression of the instruments

Table II. Specialization, competition, diversity and employment growth in Mexico by state

All these cases conform with MAR type of externalities, where specialization leads to information and knowledge spillovers and to greater employment.

4.3.2 Competition of industries. Table I also shows the impact of competition (C_{es}) on employment, measured by β_2 in the three cases considered: (a) global, (b) state and (c) cluster. Greater competition of industries positively affects employment growth. The magnitude is much lower than the parameter of specialization and the sign is consistent with the results of Lee *et al.* (2005) in Korea, but contrary to the global results found by Combes (2000) in France. However, positive coefficients are in line with predictions by Jacobs (1969) and Storper (1995a, 1995b), as well as with Porter (1990, 1998): competition of firms and industries in specific geographic areas generates rapid growth rates of productivity. In a dynamic and competitive environment, industries have incentives to innovate. States with a wide range of industries motivate productivity growth and employment, particularly with competing clusters, rather than monopolies or oligopolies. From Lee's *et al.* (2005) results, one infers that, for employment growth, it is better to have a great number of clusters and industries competing in the same geographic area, rather than few clusters/industries competing in environments of greater industrial concentration.

4.3.2.1 Competition and employment by state. Table II and Figure A1 show the impact of competition on employment growth by state. In contrast with the global results, where the positive effect of competition on employment growth prevails, in terms of particular states, the results are mixed. Consistent with MAR type of externalities for the negative cases such as Tamaulipas, Campeche and Quintana Roo, low competitive environments lack incentives to innovate. Firms may regard innovation as high cost and for this reason, they would maintain same dimension – or disappear as the life cycle of their products reaches maturity (Lee *et al.*, 2005). For the positive cases such as Morelos, Tlaxcala or Baja California Sur, industrial competition brings out positive productivity shifts and greater employment.

4.3.2.2 Competition and employment by industrial cluster. Only in few industrial clusters we find meaningful positive impact of competition on employment, greater than 0.100 (Table III and Figure A2). Power generation and transmission, apparel and communication equipment are clusters in which a competitive environment favors productivity and employment creation. Communication equipment and clothing clusters present positive impacts of competition on employment, which overcome the negative impact caused by specialization. The dynamics of industrial competition in these clusters is such that firms innovate and create jobs.

Industrial clusters where competition unwraps a negative impact on employment growth reveal relatively low levels of productivity and limited capacity to create jobs. Combes (2000) explains that a negative competition estimator is the result of local segmented markets, associated with few or none knowledge transmission and no information spillovers.

4.3.3 Industrial diversity. While specialization captures the force of externalities from inside a cluster, diversity is an externality between the clusters operating in a state – see Beaudry and Schiffauerova (2009). From our global results, we find that diversity also has a negative impact on employment growth in Mexico. In Table I, we see that the magnitude of this coefficient is on average lower than the magnitude of specialization. Against the hypothesis of Jacobs' model, the global estimations suggest that states with diverse clusters do not seem to generate the conditions for innovation and employment growth. According to Jacobs, it is possible that information exchange, cooperation and complementarities (urban economies) are scarce. It is also possible that the diversity effect is conditioned by inter-regional scale economies (Combes, 2000). The negative sign shows that closely related industries are releasing employment, maybe because of mature production processes.

4.3.3.1 Diversity and employment by state. The effect of diversity on employment growth by each state shows a very different picture than the global estimations (observe Table II and Figure A1). Estimated parameters by state are, in fact, much greater and have a greater dispersion than those of global regressions. Most estimated parameters of diversity are positive and greater than specialization and competition parameters. The state of Campeche stands out as the region with the greatest positive effect of diversity on employment growth. The states of Hidalgo, Guerrero and Tabasco are the closest followers with 0.499, 0.467 and 0.439, respectively. These are states with traded industries within a diversified environment taking advantage of information and knowledge spillovers, which, in the end, leads to the creation of more employment.

Table III. Specialization, competition, diversity and employment growth in México by cluster

Cluster	Specialization[a]	Competition[b]	Diversity[c]	Constant	*n*
High-tech clusters					
Aerospace vehicles and defense[d]	−0.089	omitted	−0.026	0.839	6
Analytical instruments	−0.018***	−0.062	−0.002*	0.123***	129
Biopharmaceuticals[d]	−0.065***	0.008	0.000***	0.071	94
Chemical products	−0.004	0.005	−0.001***	0.012	336
Communications equipment[d]	−0.276***	0.360***	−0.010***	−0.474*	56
Information technology	−0.326***	−0.053***	0.001	1.237***	152
Medical devices[d]	−0.019	0.092***	−0.002**	−0.545***	40
Service clusters					
Business services	0.114***	0.006**	−0.004***	−0.070**	702
Distribution services	−0.033***	−0.009***	0.002*	0.151***	565
Education and knowledge creation	−0.111***	−0.006	−0.001***	0.150***	587
Entertainment	0.003	0.008***	−0.003***	−0.076***	770
Financial services	−0.133***	0.047***	−0.001	0.033	410
Heavy construction services	−0.274***	−0.005	−0.002***	0.355***	771
Hospitality and tourism	0.000	−0.069***	0.000	0.090***	669
Oil and gas products and services	0.083***	0.152	−0.001	−0.599***	92
Power generation and transmission	−0.391***	0.374***	−0.001***	0.219***	87
Transportation and logistics	0.021***	−0.011***	−0.001***	0.047***	583

(*continued*)

Table III.

Cluster	Specialization[a]	Competition[b]	Diversity[c]	Constant	n
Other manufacturing clusters					
Agricultural products	−0.080***	−0.016***	0.000	0.289***	322
Apparel	−0.057***	0.187***	−0.002***	0.017	376
Automotive	−0.057***	−0.013	−0.002***	0.156***	390
Building fixtures, equipment and services	−0.215***	−0.007	−0.003***	0.316***	375
Construction materials[d]	−0.043***	−0.006	−0.003***	0.151***	187
Fishing and fishing products	−0.032***	0.026	−0.008***	0.142***	175
Footwear[d]	−0.036	0.004	0.000	−0.119	86
Forest products[d]	−0.091***	0.000	−0.003***	0.182***	219
Furniture[d]	−0.076***	−0.130*	−0.001***	0.215***	87
Heavy machinery	0.059**	−0.003***	−0.001	−0.045	171
Jewelry and precious metals	−0.063***	0.002	−0.005***	0.212***	155
Leather and related products	−0.218***	0.003***	−0.003***	0.208***	173
Lighting and electrical equipment	−0.020	−0.016	−0.001*	0.201	91
Metal manufacturing[d]	0.018*	0.003*	−0.002***	−0.029	440
Motor-driven products[d]	−0.054***	−0.042	0.000	0.257*	143
Plastics	−0.052***	0.002	−0.002***	0.101***	322
Prefabricated enclosures[d]	−0.068***	0.429	−0.004***	0.179	132
Processed food	0.091***	−0.019***	0.000***	−0.046***	1072
Production technology[d]	−0.136***	0.002***	−0.005***	0.166***	170
Publishing and printing[d]sporting, Recreational and children's	−0.267***	0.000	0.002***	0.232***	562
goods[d]	−0.111***	0.031***	−0.005***	−0.105	82
Textiles[d]	−0.045***	−0.049***	0.002***	0.386***	343
Tobacco[d]	−0.022	0.014	−0.005*	0.087	15

Notes: ***, ** and *Significance at the 1, 5 and 10% levels, respectively; [a] specialization elasticity; [b] competition elasticity; [c] diversification elasticity; [d] in these clusters, the Durbin-Wu-Hausman does not reject the exogeneity of specialization; hence, estimations with OLS are presented. The rest of the cases use size variable as a specialization instrument

We find that in the state of Coahuila, specialization and diversity provoke a simultaneous positive impact on employment growth. In three states (Baja California, Hidalgo and Chiapas), there is a positive effect of industrial diversity, over compensating the negative effect of specialization; while in the states of Chihuahua, Nuevo León and Sonora, the negative impact of specialization cancels out the positive diversity effect.

We find three states with negative elasticity, lower than unity (Zacatecas, Tlaxcala and Aguascalientes). The negative sign may indicate the presence of relatively mature industries, which within a diversified environment do not take advantage of (scarce) knowledge and information spillover. Cingano and Schivardi (2004) argue that negative diversification, together with negative specialization are likely due to industry congestion and possibly to economic shocks.

4.3.3.2 Diversity and employment by industrial cluster. In general, diverse industrial environments within clusters exert a negative impact on employment creation (see third column of Table III and Figure A2). The overall effect is very weak and the evidence is inconclusive. Our results suggest that diversity is not a competition force within clusters that could explain employment creation.

5. Discussion and policy implications

This paper contributes to the debate on the existence of MAR, Jacobian and Porter externalities. In particular, we study the forces of specialization, competition and industrial diversity in the 32 states in Mexico, from 2004 to 2008. For the first time in Mexico, we use Porter's (1998, 2003) clusters definition to distinguish the impact of these competition forces at the industry and cluster levels.

Overall, we find that industrial specialization exerts a negative impact on employment growth within states and within clusters, indicating that traded industries in Mexico carry very little innovation, may operate in early stages of the life cycle, face high costs of employment reassignation or exhibit low adaptability. A negative impact of specialization on employment conforms with Jacobs (1969) type of externalities and confirms what other studies have found in France (Combes, 2000), Korea (Lee *et al.*, 2005) and the USA (Delgado *et al.*, 2014).

The estimations within each state and each cluster also show, in general, a negative specialization parameter. Only a couple of states in Mexico (Distrito Federal and Coahuila) and six traded clusters (business services, processed foods, petroleum and gas products, construction machinery, transportation and metal manufacturing) show a positive effect of specialization on employment growth. These cases align with Marshall type of externalities, where specialization leads to more employment as a result of greater knowledge transmission and positive spillovers.

The sources of a negative effect of specialization on employment growth are varied. We should remember that we are examining traded clusters, those containing the more dynamic industries in the country. Hence, early stages of the clusters and higher costs are more plausible explanations than low innovation or low adaptability. Discerning the importance of these sources is a must for the correct design of industrial policy by type of clusters.

We also find that competition generates more employment on average. The magnitude of the parameter is weaker compared to specialization and the cases are evenly distributed, i.e. we observe a similar number of positive and negative cases in both state and cluster levels. The cases with positive impacts of competition on employment growth are consistent with Jacobs (1969), Storper (1995a, 1995b) and Porter (1990, 1998), indicating that more competition in specific geographic areas drive a rapid growth of productivity and employment. A positive effect of competition on employment is also found by Lee *et al.*

(2005). Competition is a relatively more important force in the states of Morelos, Tlaxcala and Baja California Sur than in other states. Meanwhile, power and energy transmission, communication equipment and customs have the greatest competition coefficients. In these clusters, the competition environment motivates innovation and job creation.

We also find negative estimates in the coefficient of competition (Combes, 2000, also finds negative coefficients in France). At the state level, Tamaulipas, Campeche and Quintana Roo report the lower coefficients, while the clusters of furniture, tourism and IT are those with the deepest negative impact of competition on employment. For all these cases, we conjecture in line with Combes (2000) that lower employment after greater competition reveals local segmented markets, with low knowledge transmission and no information spillovers. These are all possible patterns of industrial dynamics in Mexico.

Industrial diversity has greater and more significant impact on employment growth within states than within clusters. We find a contrasting scenario where diversity has a positive effect on employment in most of the states in Mexico; some of them with large elasticities such as Campeche (3.627), Hidalgo (0.499), Guerrero (0.467) and Tabasco (0.439). In all these cases, greater industrial diversity associates with greater employment. Also, diverse traded industries in most states promote greater employment – see Beaudry and Schiffauerova (2009). This result is much in line with Jacobs' model, where diverse traded industries generate the conditions for innovation and employment growth. The industrial environment at the aggregate states level is providing industries with abundant opportunities to cooperate and complement (urban economies).

Surprisingly, the a priori industrial diversity environment does not explain much employment growth at the level of clusters. The sign of the coefficients is negative, sign that prevails in most traded clusters: employment growth actually responds very weakly to diversity within each cluster. In terms of policy, this effect indicates that states can promote greater industrial diversity to enhance employment growth overall, but little could be achieved by promoting industrial diversity within the clusters.

All in all, the study of industrial clusters using Porter's methodology allows us to confirm that specialization and competition forces drive the dynamics of employment growth in Mexico. While specialization exerts a negative influence on growth, given the conditions of costs and low adaptability, competition promotes innovation and in the end, generates employment in most industrial clusters. While more employment could be achieved with industrial policies oriented to more diversity in general, little could be achieved if industrial diversity is encouraged within clusters.

A future extension of this study should consider local and natural-driven clusters to compare the dynamics of growth by region and by groups of closely related industries. Also, it is important to investigate the specific features that drive the effect of specialization on employment growth in Mexico. Is the negative effect the result of low adaptability to shocks? To what extent? Is it because a given specific cluster is at early stages of its industrial cycle? These questions could be investigated within the dynamics and patterns of industrial development for each of the clusters using the recently proposed definitions by Delgado *et al.* (2016).

Notes

1. The database management and integration process was performed by Pablo Nuño, Neils Ketelhohn and the author. Rich Bryden from the ICS validated the procedure and final database configuration.
2. Delgado *et al.* (2014) have a similar study for the USA, while they extend to study the convergence of related complementary clusters.

3. As a comparison note, traded clusters in the USA included 589 industries in 2005 and generated 32.8 million jobs – see Delgado *et al.* (2014).
4. Delgado *et al.* (2014) also model these fixed effects for the USA.
5. Some studies have used the size of the cluster as a proxy for competition environment. Some of these studies are found in Henderson (2003) and Ejermo (2005), who also note a close relation between size and specialization. Combes (2000) used this variable as a measure of cluster dimension.
6. Robust Durbin-Wu-Hausman tests show that specialization can indeed be considered endogenous and that $size_{sc}$ is a valid instrument. Other regressors in the test used the first lag as instruments.
7. Note that not all Mexican states have activity in the 41 traded clusters.
8. Combes notes that the inverse relation between specialization and employment growth can additionally represent a counter-cyclical behavior of localization economies.

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Appendix

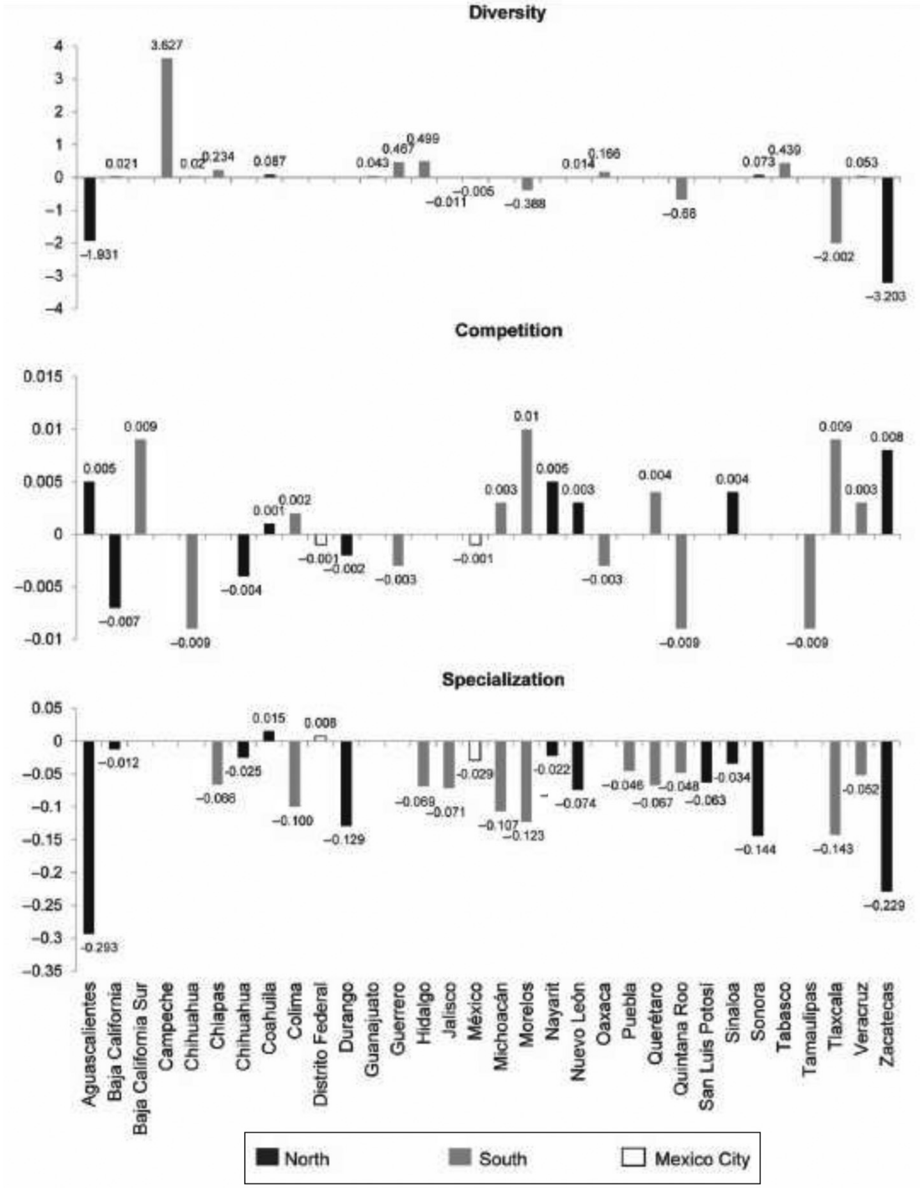

Figure A1.
Forces of competition by state

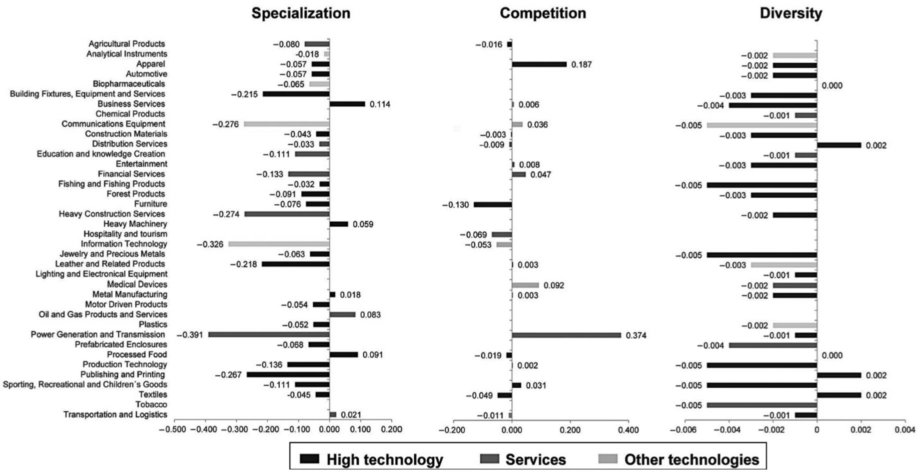

Figure A2.
Forces of competition by traded cluster

Table AI.
Partial correlation between explanatory variables and the instrument

Variable	y_{sz}	$spec_{ec}$	$size_{ec}$	$comp_{ec}$	div_{ec}
Employment growth (y_{sz})	1.0000				
Specialization (S_{sc})	−0.1683	1.0000			
Size ($size_{sc}$)	−0.1887	0.5498	1.0000		
Competition (C_{sc})	0.0357	−0.0390	0.0856	1.0000	
Diversity (D_{sc})	−0.1372	0.0083	0.5701	0.1861	1.0000

Source: Mexican cluster database

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