Article

Evolution of the specialization and competitiveness of lemon production in Mexico

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Abstract

The objective of this research was to study the specialization and competitiveness of lemon production in Mexico. The analysis methods were the Location Ratio, the Shift and Share and an analysis of specialization and competitiveness was integrated. The results show a reconfiguration in the productive structure. Nine specialized and competitive states stand out at the national level. The states with the highest growth prospects for this activity are those that make up the Gulf of Mexico coast. Specialization and competitiveness are related to the natural conditions of the producing regions, market demand and technological change.

Keywords: comparative advantages, international trade, smart specialization.

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Introduction

Citrus fruits are the main and most popular fruit crop in the world (Donkersley *et al*., 2018; Sharma *et al*., 2018), they are cultivated in most tropical and subtropical regions (Agusti *et al*., 2014). Its production increases every year due to the increase in consumer demand (Sharma *et al*., 2017). Its cultivation is not only important in economic terms, but also for its nutritional benefits in humans and animals (Sharma *et al*., 2018), which is why they are gaining popularity in the food industry around the world, Mustafa (2015). During the last decades, its production, consumption and transformation have expanded enormously hand in hand with the intensification of international trade (Liu *et al*., 2012).

The main product of the citrus industry is juice, used in many drinks or as an ingredient in many foods (Zema *et al*., 2018). In addition, other products such as jams, jellies, candied peels, flavorings and flavors for beverages, oils and essences are obtained (Mustafa, 2015; Sharma *et al*., 2017, 2018; Zema *et al*., 2018). In general, citrus fruits contain considerable amounts of lipids, sugars and acids.

Also, insoluble carbohydrates, enzymes, flavonoids, limonine, isolimonin, shell oil, volatile components, pigments, vitamins and minerals (Sharma *et al*., 2017). They contain bioactive compounds such as antioxidants, anti-cancer, anti-tumor, and anti-inflammatory drugs (Sharma *et al*., 2017). What confers one of the most desirable characteristics and demanded at present by society.

With respect to international trade, the main exporters are Spain ($798 M), Mexico ($508 M), Turkey ($336 M), Argentina ($327 M) and South Africa ($312 M). The main importers are the United States of America ($477 M), Germany ($310 M), the Netherlands ($246 M), France ($239 M) and the United Kingdom ($181 M) (Observatory of Economic Complexity, 2018). In Mexico, lemon is one of the most exported agricultural products (SIAP, 2017), with the United States of America being the main market (Donkersley *et al*., 2018).

In recent years, Mexican citrus has undergone important modifications, in the production surface and in the production location (Hernández *et al*., 2017). Three lemon species are produced nationally: Mexican, Persian and Italian and the states of Michoacán, Veracruz, Oaxaca, Colima and Tamaulipas stand out in terms of production volume (SIAP, 2017).

In this sense and derived from globalization, the economic structure of the countries has transformed at a faster rate in recent years. Various economic actors have been integrated into national economies, cooperating and competing at the same time in the same markets, with which very complex economic and productive systems have been established (Vargas-Canales *et al*., 2016; Vargas-Canales *et al*., 2018). Furthermore, the increasing commercial and financial integration between the different groups of countries allows observing a certain synchronization of economic life, which is promoted by the competitiveness model in which they are immersed.

The term synchronization refers to the movement in phase of the economic cycles of two or more countries (Mejía *et al*., 2006). It is convenient to clarify that it is not only about an economic or commercial synchronization, but about life patterns. Therefore, to adapt to this highly competitive

dynamic, it is also necessary to match the productive activities and technological innovations that best respond to the economic cycles of capital reproduction (Vargas-Canales *et al*., 2016). It must be mentioned that adaptation is a key process in capitalism and in general its development will correspond to the technological paradigm of the cycle in question (Jiménez (2014).

So today, international trade has great effects in practically all economic aspects and areas of society. For authors such as Martin (2018), it is possible to observe positive effects for the consumer, productivity gains of companies, changes in prices and transformation of consumption patterns. In addition, participation in international markets makes it possible to take advantage of regional differences in terms of endowment of resources, capacities and skills.

It is also argued that international trade allows consumers to benefit by obtaining a greater variety of products and of better quality. Furthermore, in the long term and derived from market forces, there are transformations of the productive structures and the changes generate a trend towards the specialization of the regions.

In recent years, Mexico has signed various trade agreements with several countries, among which the Free Trade Agreement with North America (NAFTA) stands out, due to the trade volumes involved and the relative importance for the economies that participate in it. This treaty involved, among other things, the elimination of tariffs and most non-tariff trade barriers on a wide range of agricultural products, and included provisions on rules of origin, safeguards, and sanitary and phytosanitary standards (Ghazalian, 2017).

The economic impact that NAFTA has had is difficult to measure since international trade is influenced by numerous variables (Villareal and Fergusson, 2017). However, economic and social benefits have been found for the Mexican economy as a whole, but these have not been uniformly distributed throughout the country (Lederman *et al*., 2005; Blecker and Esquivel, 2010; Beghin, 2015; Villareal and Fergusson, 2017).

The reality is that various changes in the country's productive structure and different coupling processes have been generated since its signing. However, not all productive activities have important links with the outside. However, this partial synchronization is a shock mechanism that modifies the country's productive structure (Vargas-Canales *et al*., 2016) and that stimulates regional and local productive specialization processes (Krugman, 1993).

Historically, different stages of agricultural specialization have occurred. In this sense, Mexican politics has sought to favor the concentration of agricultural economies, taking advantage of spatial proximity and promoting the development of agro-clusters and collective activities (Ayala *et al*., 2012; SAGARPA-FAO, 2013; Sánchez, 2014). The Mexican agricultural sector presents a growing specialization of the regional strategic productive resources. Which are oriented to crops with a high commercial value in the national and international market. Among which vegetables and fruits stand out (González, 2013).

Thus, to achieve competitive advantages and sustainable and sustainable comparative advantages in the regions it is important to have: 1) an endowment of unique natural resources; 2) human resources with extensive knowledge related to production systems; 3) use of appropriate agricultural technology; and 4) adequate interactions of the set of economic agents. However, achieving a virtuous circle of the above elements is almost impossible without proper policy. In this sense, the regional innovation systems approach is a fundamental tool for the design and implementation of smart specialization strategies (Asheim, 2018). Smart specialization is based on the identification of core and potential competencies of the regions to make the innovation process more efficient (Vlčková et al., 2018).

In this way, it would be possible to promote regions with the capacity to maintain adequate dynamics in their innovative processes, with identity and sustainability. In this sense, according to Martin (2018), the most important challenges are related to understanding the driving forces of world agricultural markets, in trade policy and in guaranteeing food security. This policy is subject to the rules of free trade under the idea of taking advantage of cheap products from abroad to favor local consumers and generate foreign exchange through export products.

The idea that the market is the main force behind specialization goes back, at least, to Adam Smith (Smith, 1976). For Smith, a larger market allows for a greater division of labor and greater specialization (Emran and Shilpi, 2012). This ensures an adequate demand for specialized skills, abilities and products. Simultaneously, impressive efforts have been made since the 1980s to explain regional economic dynamics.

According to Capello (2017), the knowledge accumulated over decades of the regional economy has managed to incorporate the space dimension in the analysis of the functioning of the market. However, although this idea has been an integral part of economic thought throughout the last centuries, it is surprising that there are almost no formal analyzes of the role of the market in determining the pattern of regional specialization and competitiveness (Emran and Shilpi, 2012).

In the Mexican case, lemon is one of the products most closely linked to international trade, which presents great dynamism at the national and international level. In accordance with the foregoing and considering that agricultural production responds to market demand, and that this was accentuated with the signing of NAFTA (Cruz-Delgado *et al*., 2013), it is possible that, from the entry into in operation of this treaty, a reconfiguration of the productive structure began, resulting in a process of productive specialization in Mexico.

Given the above, the objective of this research was to analyze the behavior of lemon production in Mexico from 1980 to 2016, using regional analysis techniques, in order to detect the effects of the market related to its specialization and competitiveness. The above is of practical utility for decision makers since it is a basic input for the design of specific agricultural policies.

Materials and methods

In this study, the 32 states of the Mexican Republic and their municipalities were considered as the fundamental geographic units to analyze the behavior of specialization and competitiveness of the lemon-producing regions. For the study, the value of lemon production was used as an analysis variable given the interest to define the characteristics of its relative weight over the different economies of the entities.

The information regarding the value of production was obtained through a series of data on an annual basis from the Agri-Food and Fisheries Information Service (SIAP, 2018). With this information, a database of the value of the agricultural production of the lemon crop for the years 1980-2016 was built. Subsequently, the location quotient and an analysis of structural trends were determined from the Shift and Share index. In these analyzes, the livestock and agricultural subsector was considered as a single block, excluding the product that is being analyzed, in order to have a comparison of lemon cultivation with respect to the total economy of the agricultural sector.

The information was organized as a double-entry sector-region matrix (SEC-REG), placing the agricultural and livestock sector in the columns and the regions in the rows (Boisier, 1980). Once the SEC-REG matrix was built, the location quotient (CL) calculation and the Shift and Share analysis were carried out.

The following equation was used to estimate the location quotient: $CL_i=\frac{\frac{X_{ij}}{\sum_i X_{ij}}}{\frac{\sum_j X_{ij}}{\sum_i \sum_j X_{ij}}}$ in which, CL_i is the location quotient, X= is the analysis variable, i= corresponds to the sector and j= corresponds to the region (in this case, each state and municipality). According to this quotient, it can be affirmed that there is relative specialization of sector i in region j when its value is greater than 1 (Boisier, 1980; Arias and Fortich, 2010).

The coefficient is interpreted as a measure of geographic concentration, which places the advantage of each sector within a group of regions. The closer the CL value approaches zero, the less concentration of the analyzed product will be in the region and vice versa. This implies that the more the economic structure of the region differs from that of the country as a whole, the greater will be its level of specialization (Mulligan and Schmidt, 2005; Gómez-Zaldivar *et al*., 2017).

For the calculation of the Shift and Share analysis, the following equation was used (Boisier, 1980): $\llbracket X'_{ij}-X_{ij}= \Delta X_{ij}=X_{ij}r+X_{ij}(r_i-r)+X_{ij}(r_{ij}-r)$ $r=\frac{\sum_{i=1}^{S}\sum_{j=1}^{R}(X'_{ij}-X_{ij})}{\sum_{i=1}^{S}\sum_{j=1}^{R}X_{ij}}$ $r_i=\frac{\sum_{j=1}^{R}(X'_{ij}-X_{ij})}{\sum_{j=1}^{R}X_{ij}}$ $r_{ij}=\frac{X'_{ij}-X_{ij}}{X_{ij}}$. In which, the term $X_{ij}r$ corresponds to the total effect; the second $X_{ij}(r_i-r)$ deals with the sectoral or structural effect, while $X_{ij}(r_{ij}-r)$ concerns the regional or competitive effect. The exchange and participation analysis assesses the growth differential of the sectors analyzed in the studied regions. This is one of the most widely used dynamic analysis methods, due to its analytical possibilities and the information necessary to construct it (Dunn, 1960).

It was raised in the sixties, with which it tried to answer questions such as, which regions show the highest growth? and if the latter can be attributed to: i) a global or national effect (sum of regions); ii) a sectoral (structural) effect; and iii) a regional (competitive) effect (Camacho-Vera *et al*., 2017).

Regarding the sectoral effect, it expresses the positive or negative impact of the growth of a specific sector, above or below the national growth rate. The regional or competitive effect reflects the dynamism of a sector in a region, contrasting it with that same sector at the national level (Boisier, 1980; Camacho *et al*., 2017). Finally, an integration of the indicators was carried out for their better understanding and to obtain a prospective of the behavior of the specialization and competitiveness of lemon production.

Thus, for the Shift and Share analysis, if a state has a positive effect in all three areas (national, sectoral and regional), it will obtain a maximum value of 3 and if they have a negative effect it has 0 and in the case of CL, the effect positive or negative was determined based on its change in the analysis period (Table 1).

Table 1. Method of integration of the indicators to determine specialization and competitiveness.

National effect	Sector effect	Regional effect	Δ CL (1981-2016)	Specialization and competitiveness	Value
Shift and Share			Specialization		
-	-	-	-	-	0
+	-	-	-	+	1
+	+	-	-	++	2
+	+	+	-	+++	3
+	+	+	+	++++	4

Elaboration based on Boisier (1980); Mulligan and Schmidt (2005); Arias and Fortich (2010); Camacho *et al*. (2017); Gómez-Zaldívar *et al*. (2017).

Results and discussion

Location quotient

In recent years, the production and marketing of lemon in Mexico has increased. The location quotient results show a strong expansion of regional specialization of lemon production. As can be seen for 1980, in several states of the republic the cultivation of lemon had a considerable relative importance with respect to the total of its agricultural economy (Figure 1).

In six states of the republic, lemon production exceeded national behavior, in the case of Colima up to 40 times more. For 2016 it is possible to observe an important change regarding the specialization in this crop, the specific weight of the state of Colima, Michoacán and Guerrero is reduced, that of Veracruz, Yucatán and Tabasco increases. On the other hand, Oaxaca, Quintana Roo and Tamaulipas appear as specialized (Figure 2).

Figure 1. Specialization of lemon production in Mexico in 1980.

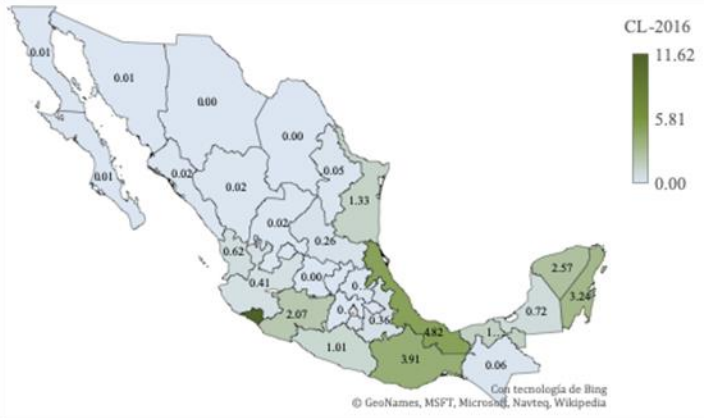

Figure 2. Lemon production specialization in Mexico in 2016.

With regard to specialization at the local level, Table 2 shows the seven states and their municipalities with the highest level of specialization in the Mexican Republic. It is possible to observe that the specialization of lemon production presents a relatively balanced spatial distribution. In other words, the relative importance with respect to the total of its agricultural economy in the specialized municipalities is similar, with the exception of Manzanillo in Colima; Santiago Laollaga in Oaxaca and González in Tamaulipas (Table 2).

Table 2. Local specialization of lemon production in Mexico (2016).

State	Municipality	CL
Colima	Manzanillo	19.03
Veracruz	Martínez de La Torre	1.01
	Tlapacoyan	1.01
	Atzalan	1.01
	Coxquihui	1.01
	San Rafael	1.01
	Carrillo Puerto	1.01

State	Municipality	CL
	Misantla	1.01
	Nautla	1.01
	Paso del Macho	1.01
	Papantla	1.01
Oaxaca	Santiago Laollaga	37.93
Quintana Roo	José María Morelos	1.01
Yucatan	Temozon	1.27
	Oxkutzcab	1.04
	Peto	1.04
	Dzan	1.03
	Ticul	1.03
	Maní	1.03
	Tzucacab	1.03
	Teabo	1.02
Tabasco	Huimanguillo	1.10
Tamaulipas	González	11.52
	Gómez Farías	1.01
	Padilla	1.01

Shift and Share Analysis

The results of the Shift and Share analysis indicate that nine states presented competitive advantages in the production of the lemon crop with respect to other producing regions of Mexico. The nine states show a positive effect at global (sum of regions), sectoral (structural) and regional (competitive) levels (Figure 3). Lemon production in these regions, in the analysis period, had a better performance with respect to national agricultural growth and growth in the sector. In other words, the best conditions were presented for the expansion and trade of the crop.

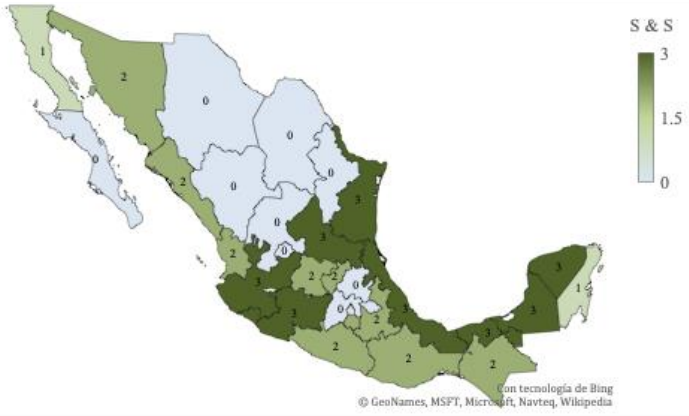

Figure 3. Shift and Share analysis of lemon production in Mexico (1980-2016).

Specialization and competitiveness

Regarding the integrative analysis on specialization and competitiveness, the results show that the states that make up the Gulf Coast of Mexico are the ones with the highest values (Figure 4). This, due to its natural characteristics and the evolution of its lemon production systems, which suggests, will be the most specialized and competitive region. At the second level is Colima, Michoacán, Jalisco, San Luis Potosí and Oaxaca. This indicates that these states also present conditions for the development of this activity. Another aspect that stands out is that cultivation has positioned itself as a good alternative and has increased its importance in the economy.

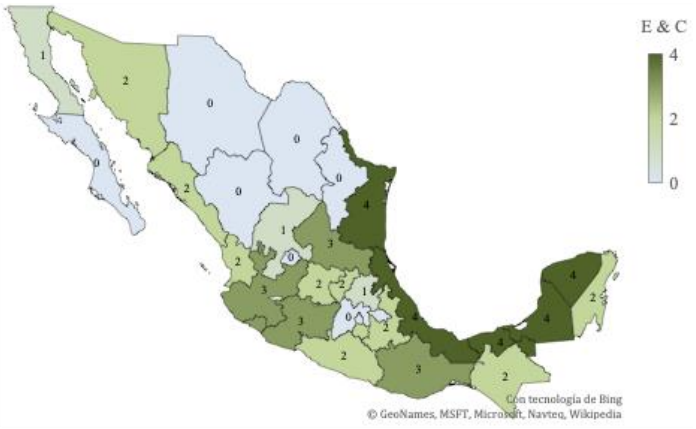

Figure 4. Prospective on the specialization and competitiveness of lemon production in Mexico.

Discussion

Lemon cultivation is one of the main fruit trees produced in Mexico (Magaña *et al*., 2010; Ramírez *et al*., 2008). The increase in its production is related to the success of the crop in the international market (Liu *et al*., 2012). Thus, as a first effect of strong international demand, Mexico's production frontier expanded. This caused changes in the production structure and in the degree of specialization in the regions where it is grown.

It is worth mentioning that, in terms of the production of limes acid, that of the Mexican lemon (*Citrus aurantifolia* Swingle) is the most important for the national market (Zea-Hernández *et al*., 2016) and its production is concentrated in Colima, Michoacán and Guerrero (Ramírez-Abarca *et al*., 2008). Secondly, there is the Persian lemon (*Citrus latifolia* Tanaka), of more recent expansion and oriented to cover international markets.

Its production is concentrated in Veracruz, Quintana Roo, Oaxaca, Yucatán and Tabasco (Hernández Trujillo and Botello Triana, 2017). Finally, the yellow or Italian lemon (*Citrus limon*, Burm), whose production is aimed at satisfying the demand of the soft drink industry, is concentrated in Tamaulipas and San Luis Potosí.

It is clear that the degree and the way in which production was restructured is directly related to the natural conditions of the regions where the crop is located, the demand of the national and international market, the available infrastructure and the technological change of the systems of

production. According to the results and the evolution of its lemon production systems, the most specialized and competitive region will be the one that integrates the Gulf of Mexico in the production of Persian lemon. In general, these are ideal tropical and subtropical regions for cultivation (Agustí *et al*., 2014).

This is related to two determining factors: 1) Veracruz has developed an important infrastructure related to the production of Persian lemon (Fernández-Lambert *et al*., 2015); 2) the relative proximity to the US, which is the main world market for Persian lemon, of which Mexico is the main supplier (Arias and Suárez, 2016). Furthermore, it is important to mention that Veracruz leads the production of Persian lemon for export in the region and the production of the rest of the Persian lemon producing states has a strong link with its agro-industry.

This does not mean that the rest of the lemon producing regions disappear, but it may not maintain its specialized character. However, as Buendía (2013) mentions, competitiveness does not arise spontaneously, but is the result of appropriate policies. Citrus production is an activity that is carried out for long-term purposes (Hernández-Trujillo and Botello-Triana, 201), in this sense, policies for promoting infrastructure, research and technological development must be built with the same projection over time.

On the other hand, although it is true that from the economic point of view the production model based on specialization has brought great benefits, it is also to be expected that it will have negative effects on natural resources, loss of diversity, contamination and even in the human health (Tolon and Lastra, 2010; Landeros-Sánchez *et al*., 2011). It is important to mention that species diversity stimulates productivity, stability and resilience in ecosystems (Hajjar *et al*., 2008; Cabell and Oelofse, 2012; Cadotte *et al*., 2012; Hooper *et al*., 2012).

Furthermore, for decades the negative effects of agro-export production dynamics on traditional production systems have been questioned. Their questioning is even related to the loss of customs, traditions and knowledge (Hernández Xolocotzi, 1988). It is also argued that excessive dependence on external trade flows generates economic dependency, weakens sovereignty and puts food systems at risk (Otero *et al*., 2013; Rubio, 2014; Ortiz *et al*., 2016). Likewise, intensive and monoculture agriculture is highly dependent on the use of external inputs such as fertilizers, agrochemicals, fuels, machinery, among others.

Derived from the above and considering that the main challenges facing world agriculture, governments and society as a whole, are to satisfy the demand for food and maintain sustainable levels of natural resources (Pérez and Landeros, 2009), it is necessary to question ourselves about the sustainability of these production systems. In this same sense, for this activity to remain a viable alternative to promote rural development, the challenges in terms of competitiveness and productivity must be addressed considering the technical, social, organizational, economic and environmental situation (Partida and Meza, 2017).

On the other hand, at present there has been no emphasis on the articulation and relationship of the above, nor among the actors present in the territory, who are the ones who configure the production systems. In addition, the advantages related to the spatial proximity of companies have not been considered in the proposal of alternatives, such as the case of an agro-cluster type integration.

These limitations make it difficult to take full advantage of the advantages related to economies of scale and potential market niches (García-Sánchez *et al*., 2018). According to Vargas-Canales *et al*. (2018), it is necessary to think about collective development schemes, which consider the characteristics and interactions that develop and evolve in the territories, in order to propose a comprehensive policy.

In such a way, the regional innovation systems approach is an ideal and fundamental tool for the design and implementation of long-term smart specialization strategies (Asheim, 2018), according to the particularities of each region and based on knowledge, technology and the environment to achieve sustainable agri-food systems.

Conclusions

Lemon production presents changes in its productive structure and in its spatial specialization. This transformation is directly related to the natural conditions of the regions that present specialization and competitiveness, which are ideal for the optimal development of the crop. But above all with the growing national and international demand that has favored the development of infrastructure and the development of technological innovations that have been adopted and adapted effectively in production systems.

The spatial concentration of lemon production is due to the particularities that give them comparative advantages compared to other geographic areas. In general, specialization and competitiveness, considering the historical behavior of this crop, is expected to expand further. Specifically, the strongest growth is expected to occur in the states that make up the Gulf of Mexico coast and to be from Persian lemon.

On the other hand, for this activity to remain a viable alternative to promote sustained economic development, the challenges in terms of specialization and productivity must be addressed from a systemic perspective and considering technical, economic, social and environmental aspects. In this sense, the regional innovation systems approach is the ideal tool to implement smart specialization strategies and achieve sustainable agri-food systems.

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