Analysis of the demand for live beef cattle in slaughter centers in Mexico, 2000-2018

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Abstract:

The analysis of the value chain in beef cattle of Mexico has focused mainly on production and final consumer; however, slaughter centers represent the main link between producers and consumers. The objective was to analyze the demand for live beef cattle in the slaughter centers of Mexico, 2000-2018. The sample considered 50 slaughterhouses, in 26 of 32 states and the demand models were estimated using the ordinary least squares method. It was possible to estimate the four best demand models by product; the price explained 43.4 % of the variability in the quantity of beef in the slaughter centers; 60.4 % for cull cows, 37.7 % steers, 33.5 % cull bulls and 28.8 % heifers. All products behaved inelastic in price (-0.17), but the demand for steers had the lowest elasticity (-0.06). The beef market presented a low average density of connections between the producers and slaughter centers analyzed (25.2 ± 43.4 %), which indicates its inefficiency. The state of Jalisco represented the main slaughter center in steers and cull cows, while Aguascalientes in heifers and cull bulls.

Key words: Steer meat, Heifer meat, Cow meat, Bull meat, Elasticity of demand, Market **density.**

Introduction

Is the price the most important variable that determines the quantity of cattle demanded in slaughter centers in Mexico? Market information in beef production systems is a public good, allowing for an allocation of resources based on maximum productivity. In Mexico, the availability of market data lacks sufficient and relevant information (data analysis), in time and in due form, for decision making. The National System of Information and Market Integration (SNIIM, for its acronym in Spanish) is one of the official institutions that provides data related to the price, quantity supplied and demanded of cattle in slaughter centers in Mexico. However, it only provides a random sample of the slaughter centers (private, TIF and municipal), price and live weight that allows estimating the demand functions.

Market research on beef in Mexico has been conducted for the consumption of live beef cattle and carcass, not so for slaughter centers, none on the efficiency of slaughter centers and all refer to case or local studies[1,2,3]. In addition, a study on the main meats consumed in Mexico confirmed a substitution effect between beef and chicken[4]; on the other hand, in other works on the regional demand for Mexican beef, an inverse and inelastic relationship between the quantity and price of beef in carcass was found[5], associated with an inelastic effect of the producer price and an elastic effect of the consumer price[6]. For its part, another study examined the effect of pork imports on domestic beef consumption and it was concluded that pork imports have a negative effect on the beef substitute market in Mexico[7]; confirming that, globally, 70 % of production is concentrated in India, Brazil, Australia, United States (USA) and New Zealand and demand in USA, Canada, EU (European Union) and Russia[8]. In another similar study, it was found that the demand for livestock products was a function of income and that, according to the trend, the volume produced and the demand for chicken meat will be satisfied, but not that of beef. Therefore, the need to do research at the level of supply center (producers) and slaughter center (consumers) in Mexico[9].

The market of meat of live cattle in Mexico is characterized by four products: steer, heifer, cull bull and cull cow[10]; steer and heifer meats are targets of the production system and the other two by-products are from the production process. The supply of the four types of meat is a function of the composition of the herd; that is, the proportion of cows, bulls, heifers, steers and calves[11]. The inventory of beef cattle in Mexico was 31.9 million head of cattle; in fattening 33.4 %, calves 25.1 %, cull 11.6 %, in development 10.3 %, replacement heifers

7.2 %, cows only for reproduction of calves 5.5 %, cows only for milk production 4.4 % and others 2.5 %. As a result, 41.8 % was marketed through intermediaries, 11.4 % in TIF slaughterhouse, 5.4 % export, 2.8 % municipal slaughterhouse, 1.9 % private slaughterhouse and others 36.7 %[12].

In 2000, just over 4.2 million t of live beef were supplied in Mexico; 43 out of every 100 t corresponded to chicken, 33 to cattle and 24 to pig; in 2018, it was just over 6.8 million t; 49 out of every 100 t corresponded to chicken, 39 to cattle and 22 to pig. This meant a 6 % increase in the supply of chicken meat and a 4 and 2 % decrease in beef and pork[13]. In turn, in 2018, the national monthly installed capacity for the slaughter of cattle was 1'108,043 heads; 49.14 % in TIF slaughterhouses, 43.36 % in municipal slaughterhouses and 7.5 % in private slaughterhouses[14]. However, only 54 % of the national monthly installed capacity is used; 63 % of TIF slaughterhouses, 47 % municipal slaughterhouses and 43 % private slaughterhouses. None of the TIF and private slaughterhouses are at 100 % of their installed capacity; and of the private sector, only Chiapas reported 100 % of its capacity used[15]. So, there is an area of opportunity in research to analyze and propose strategies to improve the productivity of beef slaughter centers in Mexico.

The productivity of a production system is measured by four elements: efficiency, effectiveness, quality and economy[16]. The efficiency of livestock production in Mexico, measured in the slaughter centers of live cattle to meat in carcass, showed that in 2019 the production of pork had the highest efficiency among meats with 79.0 %, poultry 78.1 %, turkey 74.4 %, bovine 54.8 %, ovine 51.6 % and caprine 51.4 %. In the case of beef cattle, efficiency decreased by 21.8 %, which would imply a greater number of animals slaughtered to supply national consumption[13].

Therefore, the study aimed to analyze the demand for live beef cattle in the slaughter centers of Mexico, 2000-2018. The central hypothesis is that the low capacity used of the slaughter centers is due to the location of the supply centers and slaughter centers, an installed capacity greater than that required, and that the price paid to the producer or supply center determines the number of steers, cows, bulls and heifers demanded in the slaughter centers of Mexico.

Material and methods

Four products of live beef cattle were analyzed: steer (ST), heifer (HE), cull bull (BU) and cull cow (CO) demanded in the slaughter centers of Mexico. As a demand, the number of heads of cattle slaughtered in the slaughter centers (private slaughterhouses, TIF slaughterhouses and municipal slaughterhouses) reported by the National System of

Information and Market Integration (SNIIM, for its acronym in Spanish) in the period 2000-2018 was considered.

Of 90 slaughter centers that reported activities in the analysis period, however, the sample (n= 54) considered those that reported activities throughout the analysis period: 19 municipal, 10 TIF and 4 private. These are located in 26 of the 32 states. The slaughter centers that reported activities also specialize by type of product in: steer 27 slaughterhouses, heifer 11, cull bull 17 and cull cow 23.

Since the data reported by the SNIIM lack the live weight of slaughtered animals, the heads of cattle, which allowed being in accordance with the installed slaughter capacity, were considered as the quantity demanded, instead of volume in kilograms (kg). The market price of products was deflated with the national consumer price index (INPC 2018=100)[15].

Theoretical models consider that the quantity demanded (D_j , j= 1, 2, 3, 4) of live steer (STD), heifer (HED), bull (BUD) and cow (COD) have a linear relationship with the price ($P_j, j = 1, 2, 3, 4$) of the live steer (STP), heifer (HEP), bull (BUP) and cow (COP), respectively. In its statistical form, D_j was written as:

$$D_j = f(P_j) + e$$

The models used were estimated through the Ordinary Least Squares (MCO) method proposed by Gauss and Legendre in 1808, which minimize the sum of squares of errors. The economic validation of the models was carried out by considering the economic theory that indicates an inverse relationship between the quantity demanded of heads of cattle and the price in slaughter centers.

Although, the slope of the demand function allows measuring the amount and direction of the quantity demanded in the face of changes in the price; there is the price elasticity of demand (E_P^D), which measures the change or sensitivity of the quantity demanded (ΔQ) to changes in price (ΔP_j). The E_P^D were obtained using a log-log regression model for each meat product analyzed.

$$Ln(D_j) = \ln(\beta_0) + \beta_1 \ln(P_j) + u_i$$

In this way, β_1 represents the price elasticity of demand for each of the products analyzed and measures the percentage change in the quantity demanded of heads of cattle in the face of a percentage change in their price.

The analysis of the demand for beef in slaughter centers was carried out through the analysis of social networks, which allows identifying the most important actors (slaughter centers and supply centers) and their commercial relationships[17].

Finally, to validate the results and make inference about the demand for live cattle, the statistical significance of the models was performed by considering the *p*-value and t-Student for the price regression coefficient[18].

Results

On average, during the analysis period, 2000-2018, 2.7 million head of cattle were slaughtered, distributed as follows: 40.9 % steer, 34.7 % cow, 13.8 % bull and 10.6 % heifer.

The average weight at slaughter for steer was 465.6 ± 124.4 kilograms of live weight (kgLW), heifer 472.5 ± 43.3, cow 471.5 ± 117.4 and bull 466.7 ± 53.7. The real prices of live cattle were higher for steer 32.8 ± 9.0 $/kg, heifer 27.73 ± 8.4 $/kg, cow 23.3 ± 7.6 $/kg and bull 30.0 ± 9.1 $/kg. In general, the price of the four products was homogeneous (CV= 24 %), the price of the cow presented the greatest variability (CV= 32.7 %) and that of steer the lowest variability (CV= 27.5 %).

The specialization of the supply centers for the slaughter of cattle showed that 23 of them specialize in steer meat, five in heifer, 17 in cow and 11 in bull; the other slaughter centers are based on the seasonality of meat production.

Steer meat

According to the sample, of the 37 steer slaughter centers that reported operations in 2000, in 2018 only 27 did so; while the number of steers slaughtered decreased by 10.6 %. In 2010, the four main slaughter centers slaughtered 41.0 % of the steers in Mexico (Municipal Slaughterhouse of Guadalajara 21.3 %, Naucalpan 7.3 %, La Paz 6.4 % and TIF 78 Frigorífico del Sureste 5.9 %; while, in 2018, four slaughter centers demanded 55.8 % (Slaughterhouse TIF 111 22.2 %, Municipal Slaughterhouse of Guadalajara 16.6 %, Sukarne slaughterhouse 10.5 % and Procarne slaughterhouse 6.5 %). The supply of steers occurred in 27 of the 32 states. Likewise, in the analysis period, the three main steer suppliers changed their position and importance; while in 2000, they were Jalisco (29.3 %), Nuevo León

(11.5 %) and Chiapas (11.2 %); in 2018, they were Sinaloa (22.2 %), Nuevo León (18.6 %) and Jalisco (18.2 %).

Heifer meat

In 2000 there were 11 centers specialized in the slaughter of heifers, in 2018 the same number was counted, but not the same centers; some stopped providing information and others disappeared. In 2000, a single center slaughtered 74.0 % of heifer (TIF 111 Vizur Sin) and the states with the most important slaughter centers were Guanajuato 23.6 %, Chiapas 22.3 % and San Luis Potosí 12.0 %; in 2018, Sinaloa 74.1 %, Guanajuato 10.24 % and Michoacán 8.2 %. The supply of heifer was made by 19 states in 2000, the most important were Chiapas 21.9 %, Guanajuato 14.1 % and Jalisco 11.8 %; while in 2018, there were 14 states, Sinaloa 74.1 %, Michoacán 8.2 % and Jalisco 8.0 %.

Cow meat

The cow is mainly a cull product in Mexico in all production systems. Some states are characterized by a greater slaughter for having dairy basins, such is the case of Coahuila, Durango, Jalisco, Aguascalientes, Querétaro, Chihuahua and Hidalgo. In 2000, there were 34 supply centers specialized in cow slaughter and in 2018 they reduced by 32.3 %, the most important was M.S. Guadalajara that slaughtered 27.6 % of cows. In 2000, the most important states in cow slaughter were Jalisco 34.8 %, Guanajuato 7.88 % and Chiapas 7.5 %. In 2018, they were Jalisco 30.9 %, Sinaloa 28.2 % and Aguascalientes 12.2 %. The supply of cows in 2000 was meet with production from 25 states, the most important were Jalisco 36.9 %, Chiapas 7.4 % and Zacatecas 6.6 %; while, in 2018, the supply corresponded to 21 states and the main suppliers were Sinaloa with 28.2 %, Jalisco 27.4 % and Aguascalientes 11.3 %.

Bull meat

As in the case of cow meat, bull meat comes from cull animals. In 2000, there were 14 supply centers specialized in bull slaughter, the most important were P.S. León Servicios Integrales in Guanajuato (20.7 % of slaughtered bulls), TIF 78 Frigorífico del Sureste in Chiapas (19.9%), and M.S. of San Luis Potosí (10.5%). In 2018, there were the same number of slaughter centers, but some were new; now the main slaughter centers were TIF 111 Visur in

Sinaloa with 46.5 % of bulls slaughtered, TIF Slaughterhouse in Sonora 11.7 % and Frigorífico y Empacadora de Aguascalientes 11.6 %. In 2000, the supply of bull was concentrated in 19 states; the most important were Chiapas 19.5 %, Sonora 12.47 % and Guanajuato 12.3 %. In 2018, only 14 supplied bull, the most important Sinaloa 46.5 %, Aguascalientes 16.1 % and Sonora 12.2 % of bulls offered.

Demand functions

All models for beef demand, by product, coincided with economic theory, except for bull, and were statistically significant in the coefficient of the price ($P<0.05$). For the four types of meat, the price explained 46.4 % of the number of heads of cattle slaughtered in slaughter centers, while, for all three products, just over 28 % (Table 1). Therefore, the estimated models are considered good (the law of demand holds, the price explains the variability of the quantity demanded, the P-value is <0.05, the coefficient of variation is low, and the standard error of estimate represented less than 21.2 % of the average number of heads of cattle demanded in the slaughter centers).

Table 1: Demand models

	STD	HED	BUD	COD	All
Intercept*	1.5	0.5	0.2	1.4	3.7
Slope	-9,736.9	-5,686.5	4,354.6	-19,599.0	-29,737.1
R^2	0.4	0.3	0.3	0.6	0.5
F-Ratio	16.5	15.3	0.2	25.9	14.7
Prob(F)	0.0	0.0	0.7	0.0	0.0
S.E.	3,012.6	1,474.6	13,676.1	3,852.0	7,756.3
T-Test	-3.2	-3.9	0.3	-5.1	-3.8
Prob(T)	0.0046	0.0012	0.7538	0.0001	0.00012

STD= quantity demanded of steers; HED= quantity demanded of heifers; BUD= quantity demanded of bulls; COD= quantity demanded of cows; *Millions of heads.

Price elasticity of demand

The price elasticity of demand for meat of live cattle in slaughter centers was 0.36 %; that is, inelastic and indicates that for every 1 % that the real price of beef changes in Mexico, the quantity demanded of cattle in the slaughter centers will change 0.36 %. The price elasticity of demand, by product, was also inelastic; thus, the price elasticity of demand for the steer

was 0.33 % (0.33) for 1 % of real change in its price, for the steer 0.65, bull 0.39 and cow 0.60 % (Table 2).

Table 2: Estimated demands by product and slaughter center

Demand	Intercept	Slope	R^2	Prob(T)
Steers				
M.S. Aguascalientes	36103.90	-1207.70	0.70	0.00
M.S. La Paz B.C.S.	7574.20	-150.50	0.70	0.00
M.S. Campeche	12530.50	-172.70	0.30	0.00
TIF 78 Frigorífico del Sureste	35372.60	-570.50	0.40	0.00
P.S. Perecederos y Derivados	84715.20	-4019.90	0.80	0.00
Municipal meat processor of Colima	20119.00	-410.50	0.90	0.00
M.S. Cerro Gordo	29763.10	-475.30	0.60	0.00
M.S. Naucalpan	165418.30	-5588.00	0.50	0.00
M.S. Nezahualcóyotl	159118.40	-6746.60	0.80	0.00
M.S. Tlalnepantla	26727.50	-321.00	0.60	0.00
M.S. Guadalajara	252444.00	-2608.80	0.50	0.00
M.S. Tlaquepaque	24994.70	-352.80	0.60	0.00
M.S. Tonalá	21284.60	-308.70	0.60	0.00
M.S. Morelia	46452.30	-594.30	0.50	0.00
Bodega de Productos Internacional	158031.90	-6484.60	0.80	0.00
Chamar Alimentos TIF 356	100326.20	-1186.60	0.30	0.00
Procesadora Selecta, S.A. de C.V.	90551.00	-1627.70	0.30	0.00
TIF 15 Emp. Trevino	58460.80	-1007.80	0.30	0.00
Procesadora de carnes "La Alianza"	6694.80	-108.70	0.80	0.00
M.S. of San Luis Potosí	35077.90	-496.40	0.40	0.00
Bovine TIF Cd. Obregón	12133.30	-203.40	0.30	0.00
Aric Planta TIF 170	14011.30	-325.90	0.40	0.00
M.S. Zacatecas	5823.20	-106.60	0.40	0.00
Heifers				
M.S. Aguascalientes	12204.00	-391.90	0.40	0.00
M.S. Campeche	21591.90	-865.60	0.50	0.00
P.S. León, Serv. Integral	95873.10	-2067.80	0.60	0.00
M.S. Morelia	34700.10	-326.50	0.20	0.00
Procesadora de carnes "La Alianza"	6393.50	-110.20	0.80	0.00
M.S. of San Luis Potosí	31448.00	-442.40	0.30	0.00
TIF Bovinos Cd. Obregón	12831.10	-225.30	0.40	0.00
M.S. of Xalapa	12555.40	-360.40	0.60	0.00
Aric Plant TIF 170	15498.10	-449.10	0.50	0.00
M.S. Zacatecas	4025.80	-66.80	0.40	0.00

Bulls

M.S. La Paz B.C.S.	9013.50	-233.70	0.70	0.00
M.S. Campeche	14448.40	-322.40	0.40	0.00
TIF 78 Frigorífico del Sureste	35465.70	-650.70	0.40	0.00
P.S. León, Serv. Integral	90598.60	-1530.50	0.50	0.00
M.S. Queretaro	65717.70	-1069.50	0.20	0.10
M.S. of San Luis Potosí	32320.80	-246.30	0.20	0.00
Bovine TIF slaughterhouse Cd. Obregón	14144.40	-366.00	0.50	0.00
M.S. Zacatecas	4375.10	-69.90	0.40	0.00
Cows				
M.S. La Paz B.C.S.	9516.30	-340.60	0.80	0.00
M.S. Campeche	13642.80	-327.70	0.30	0.00
TIF 78 Frigorífico del Sureste	34722.70	-646.30	0.40	0.00
P.S. La Torrena	61715.70	-3717.70	0.80	0.00
Municipal meat processor of Colima	17857.40	-825.90	0.60	0.00
M.S. Tlalnepantla	21154.20	-347.40	0.20	0.00
P.S. León, Serv. Integral	91272.80	-2275.10	0.70	0.00
M.S. Guadalajara	242265.20	-3116.50	0.40	0.00
M.S. Tlaquepaque	23580.10	-422.80	0.50	0.00
M.S. Tonalá	19068.80	-310.20	0.50	0.00
M.S. Morelia	46044.10	-813.50	0.40	0.00
A.M. Tepic	24111.70	-517.80	0.60	0.00
M.S. of San Luis Potosí	30994.00	-248.10	0.20	0.10

M.S.= municipal slaughterhouse; P.V.= private slaughterhouse; TIF= federal inspection type.

In addition, Table 2 presents the estimated demand functions both by slaughter center and by each of the products in which the theory is verified, the estimated functions were statistically significant ($P>0.05$) at the predetermined confidence level.

Networks

In Figure 1, it can be seen that in the most important supply (n= 33) and slaughter (n= 25) centers in Mexico, the concentration of live beef cattle is in four slaughter centers, near the four centers of meat consumption (Mexico City, Jalisco, State of Mexico and Nuevo León); in addition, Aguascalientes has become a collection center for the supply centers of the north of the country. Overall, the market has an efficiency of 25.2 %, which means the set of possible relationships between production centers and slaughter centers. The variance

(43.4 %) indicates that supply centers and slaughter centers receive the heads of cattle from different origin or that both seek the best price. The main slaughter center was Jalisco with 82.9 ± 38.6 % of the possible market relations, other important ones were State of Mexico 77.8 ± 42.9 %, Aguascalientes 63.7 ± 48.1 %, Guanajuato 51.5 ± 50.0 % and Nuevo León 45.6 ± 49.8 % of possible relationships. Likewise, the most important supply center was Aguascalientes, which was related to 84.0 ± 36.7 % of the slaughter centers, Jalisco 44.0 ± 49.7 % and Zacatecas 40.0 ± 49.1 % of the slaughter centers.

Figure 1: Mexico, network of cattle supplies and slaughter centers
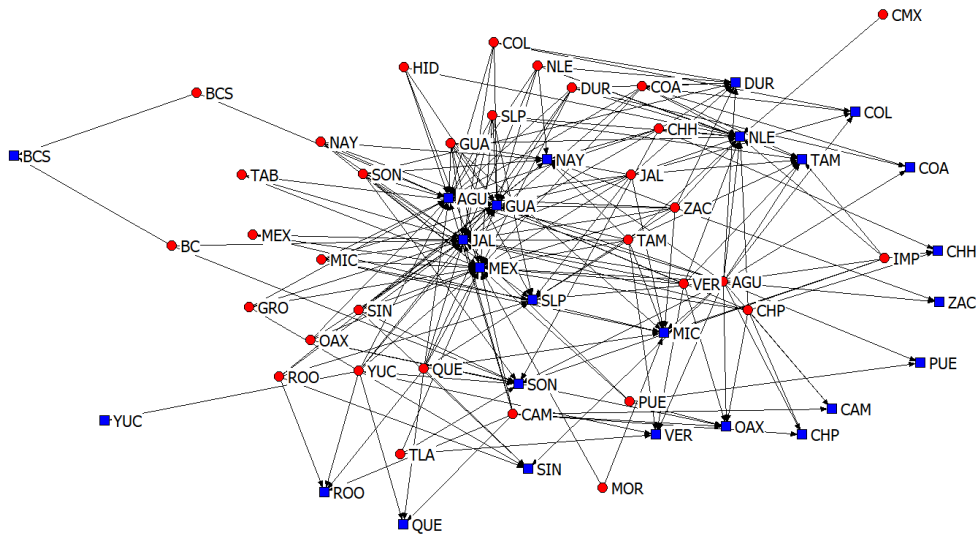
Blue color = slaughter centers and red color = supply centers.

The most important slaughter centers in steer slaughter are located in the State of Mexico, Jalisco and Aguascalientes; they receive steer from the highest proportion of states. The remotest states of the country meet their demand for steer with local production (Baja California Sur and Yucatan). The low relation (25.2 %) that the supply centers have with all the slaughter centers can be explained by the distance between supply centers and slaughter centers, in addition to the specialization in the type of animals slaughtered. In the case of Jalisco, which was related to more than 80 % of the supply centers or states, it can be explained by the geographical location, the installed capacity and the specialization in steer and cow (Figure 2).

**Figure 2:** Slaughter and supply centers for steer meat
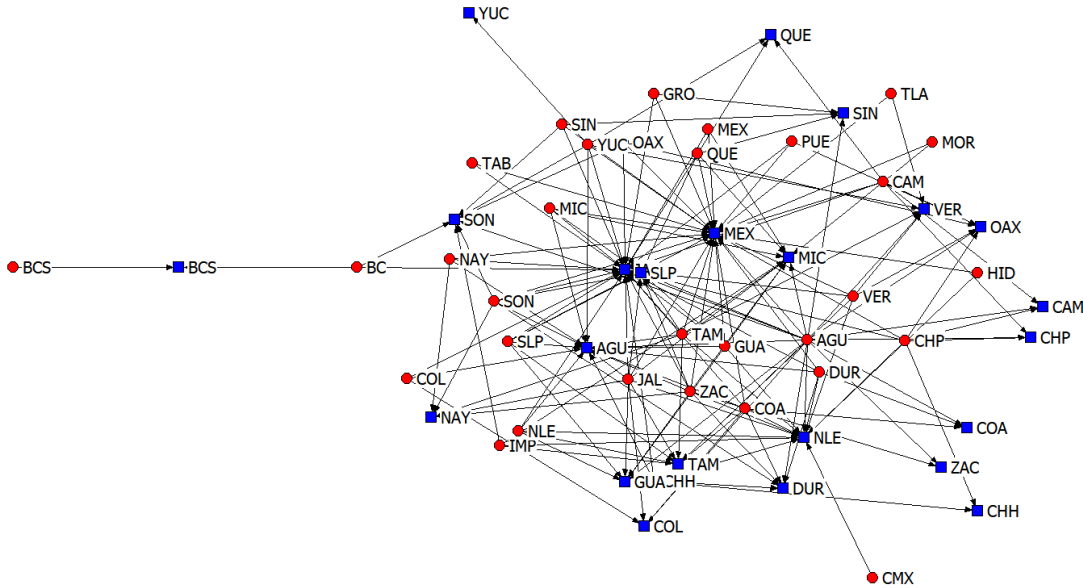
In the case of heifers, the relation of the slaughter and supply market reduces. The market of Baja California Sur is isolated from the domestic market. The average of all possible relationships was 19.4 ± 39.5 %, which means low network density and variability. The slaughter centers with the highest nodal degree or degree of influence were Aguascalientes and Guanajuato with 54.9 ± 50.1 %. Likewise, the supply centers with the greatest influence were Aguascalientes 66.7 ± 47.1 % of the supply centers, Zacatecas 38.9 ± 48.8 %, Jalisco and Yucatán 33.3 ± 47.1 %, respectively (Figure 3).

Figure 3: Slaughter and supply centers for heifer meat
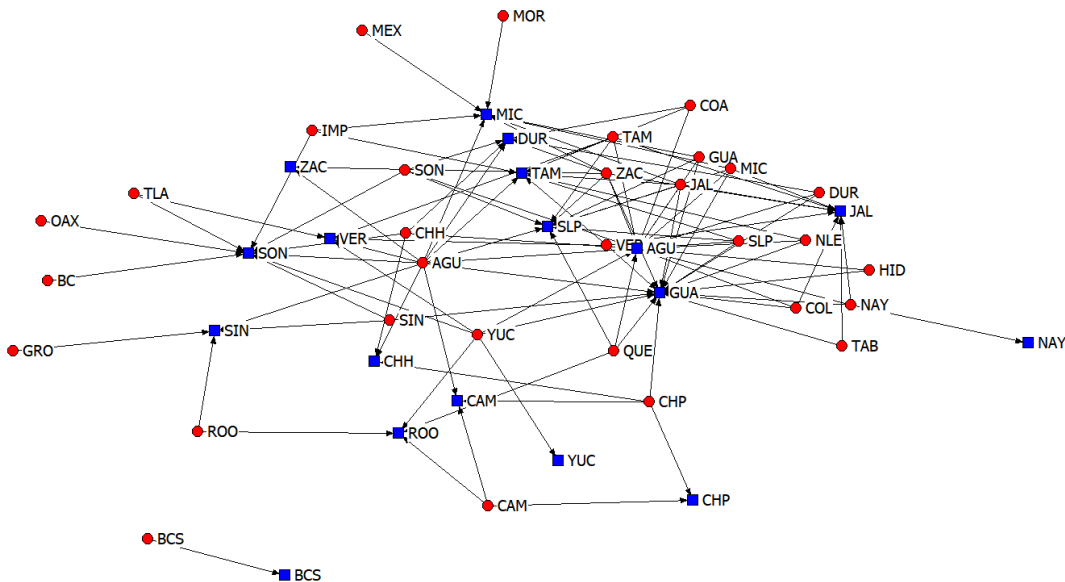
The market density for cow meat was 22.9 ± 42.0 %, meaning that approximately 23 % of the trades that could occur between suppliers and slaughter centers were achieved. The slaughter centers of Jalisco have market relations with 84.4 ± 36.3 % of the supply centers. Aguascalientes and Guanajuato are the other centers that have a commercial relationship with 53.1 ± 49.9 % of the supply centers. For supply centers, the states of Aguascalientes, Jalisco and Zacatecas had 80.0 ± 40.0, 44.0 ± 49.0 and 40.0 ± 49.1 % of their commercial relations (Figure 4).

Figure 4: Slaughter and supply centers for cull cows
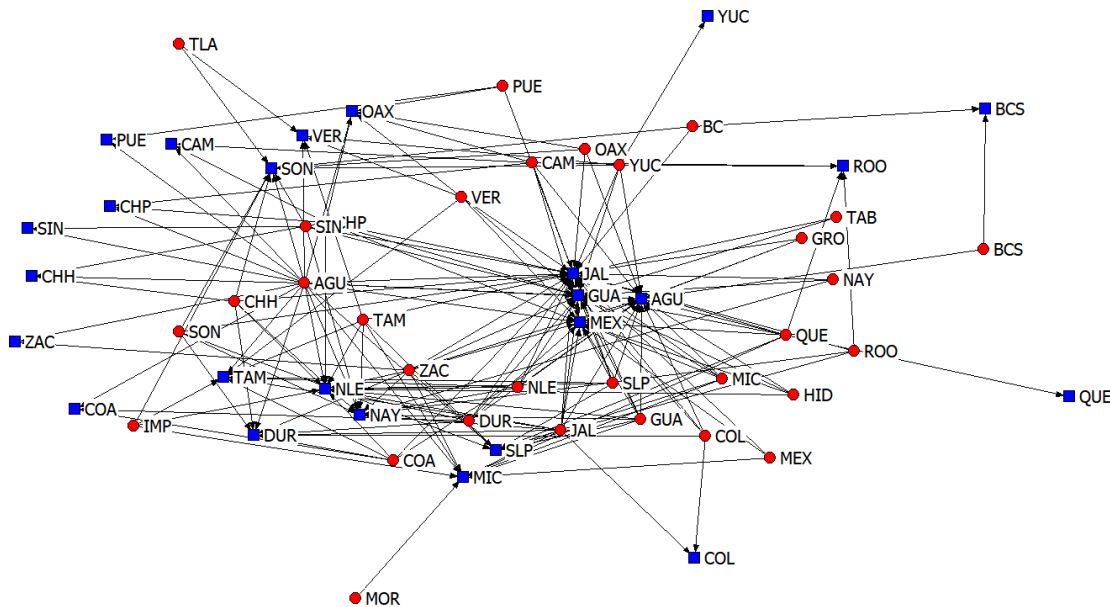
For the bull meat market, a density of 19.7 ± 39.8 % was found, the lowest of the four products analyzed. The slaughter centers of Aguascalientes and Guanajuato had exchanges of bull meat with 58.6 ± 49.3 % of the supply centers, others such as San Luis Potosí 31.0 ± 46.26 %, Durango and Nayarit 31.0 ± 46.3 %. The supply centers of Aguascalientes had exchanges with 72.2 ± 44.8 % of the slaughter centers, Jalisco and Zacatecas 38.9 ± 48.8 %, in addition to Guanajuato, Querétaro and Sonora with 27.8 ± 44.8 % of their relations with the supply centers (Figure 5).

Figure 5: Slaughter and supply centers for bull meat
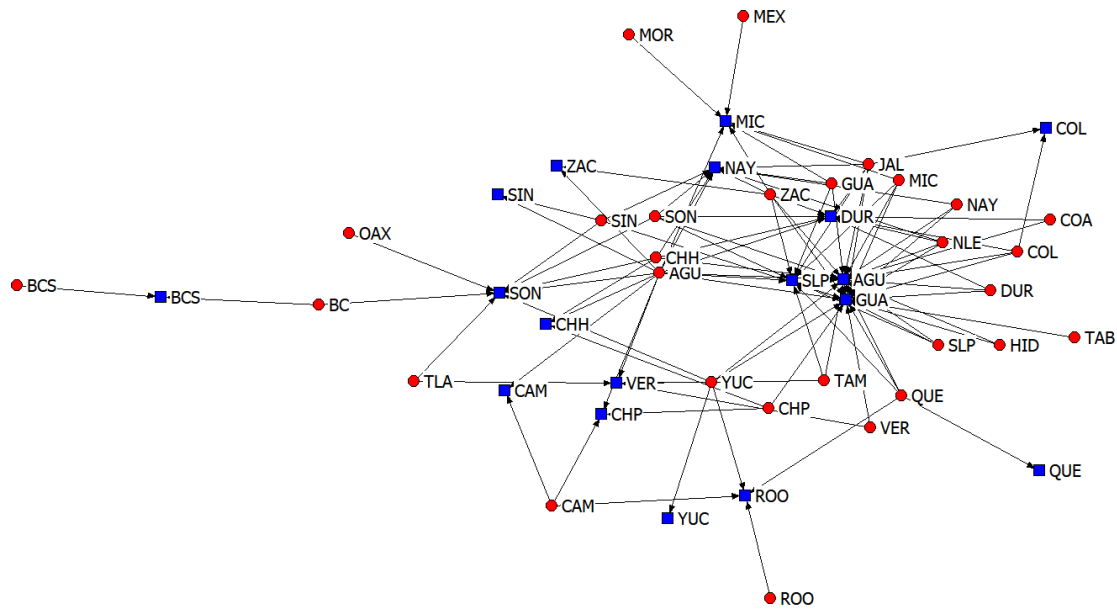
Discussion

Price elasticity of demand

The slaughter centers with elastic price elasticity of demand were Guanajuato, Nuevo León, San Luis Potosí, Jalisco, Durango, Coahuila and Sinaloa; while the rest behaved in an elastic way. One of the hypotheses of this behavior is the specialization they have in the meat products of the slaughtered animals (steer 74.1 %, heifer 90.0 %, cow 82.3 % and bull 60.2 %). The second is that, having such a low used capacity forces them to respond in an elastic manner to price changes to remain in the market; in this case, the slaughter centers with elastic price had a used capacity of 63.2 %, against 40.1 % of the inelastic ones.

Studies that discuss these results were almost nil; however, elastic price elasticities of demand for beef in Mexico were found[19]. However, this result is far from a study where a price elasticity of the demand for beef in Mexico was confirmed inelastic (-0.07) for the period 1990-2012[20] and close to that of Chile, focused on demand for beef cattle at the national level for a different period[21]. On the other hand, in an another study, an inverse response of the price of beef to the quantity demanded was found, confirming an inelastic effect[22]; while in other related works, an elastic response (-1.41) of the price of beef to the quantity demanded was confirmed, for the case of Colombia[23], while for Mexico, regionally,

inelastic price responses (between -0.15 and -0.53) to the quantity demanded of beef in carcass during the period 1996-2017[5] were confirmed.

Capacity of slaughter centers

The number of cattle slaughter centers are distributed throughout Mexico, which is consistent with the dispersion of the supply centers or production units, as well as the livestock population, they are present in 30 of 32 states. However, TIF slaughter centers exist in 20 states, private ones in 13 and municipal ones in all states.

Currently, cattle slaughter centers have an inefficiency of 46 %, which means that they could slaughter 509,700 more heads. So, the question arises: How to make slaughter centers more efficient? In this regard, it has been verified that the farmer destines cattle for supply through three marketing channels: introducer (34.8 %), butcher (58.8 %) or on their own account (6.4 %)[24]; while other studies concluded that they found that 73.0 % of cattle are sold directly to slaughterhouses and 26.0 % to intermediaries; which could explain why producers prefer to slaughter their cattle in slaughter centers far from the nearest center[25,26].

Prices in slaughter centers

The highest national average price in the slaughter centers was paid in San Luis Potosí (64.08 $/kg) for cattle from Michoacán; the lowest (15.66 $/kg) was in Nuevo León for cattle from San Luis Potosí. The slaughter centers of Jalisco (main national center) paid an average of 29.56 ± 2.90 $/kg, State of Mexico 34.27 ± 4.48 $/kg and Aguascalientes 23.93 ± 3.52 $/kg; however, the difference is not significant ($P>0.05$).

The average price for steer meat was 32.03 ± 5.59 $/kg, the maximum 58.22 $/kg in Sonora for cattle from Sinaloa and the lowest 22.20 in Baja California Sur for cattle from Baja California. The most important slaughter centers, due to their relationship with the supply centers, (San Luis Potosí) paid an average of 36.89 ± 7.33 $/kg, which is not statistically different from the national average price ($P>0.05$), nor from the second most important state slaughter center (State of Mexico).

The monitoring of the beef market in slaughter centers is carried out by the SNIIM. What can be observed is that the municipal slaughter centers maintained a decreasing trend in their monitoring from 2002 in 1.37 centers per year; in 2000 of the total number of centers

monitored, TIF centers maintained an increasing trend until 2005, constant until 2010, but decreasing to date. Private centers, since 2005, have had increasing monitoring; in 2005, of the slaughter centers monitored, 17.58 % were private and in 2018 they represented 52.47 %.

Conclusions and implications

The economic and statistical theory holds for linear models of the demand for steer, heifer and cow meat, not so for bull meat; which allowed inference to be made about the situation of the demand for meat of live beef in the main slaughter centers of Mexico. The price elasticity of demand for beef in its four products classifies them as inelastic; but it shows a greater sensitivity in the demand for heifer and less in steer. The most important slaughter centers in steer were Jalisco, State of Mexico and Aguascalientes; in heifer, Aguascalientes, Guanajuato and San Luis Potosí; in cow, Jalisco, Guanajuato, State of Mexico and Aguascalientes; and in bull, Aguascalientes, San Luis Potosí and Guanajuato. Finally, even when secondary information is available, it is insufficient, and the time to generate information for the market becomes a weakness for the first link in the value chain of beef cattle in Mexico.

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