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Article

Regional supply and demand for chicken meat in Mexico, 1996-2016

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Abstract:

Multiple variables can affect meat product supply and demand. An analysis was done of the magnitude of the effect of the main economic and technological variables that influence supply and demand of chicken meat in eight regions in Mexico during the period 1996 to 2016. A multiple linear regression econometric model was formulated for each region, including the main economic and technological variables determining supply and demand. In most of the regions, chicken meat supply reacted directly and elastically to changes in technology (average = 1.7395), directly and inelastically to the price of chicken meat (average = 0.9912), and inversely and inelastically to the prices of pork (average = -0.3686) and feed (-0.1423). In all regions demand behaved elastically in relation to population size (average = 2.0853), and inelastically in relation to the current price of chicken meat (average = -0.1698), per capita income (average = 0.2560) and the current price of beef (average = 0.0272). Population growth had the greatest effect on chicken meat consumption in all the regions. All the tested models had overall significance, although not all the predictive variables had a significant effect.

Key words: Chicken meat, Elasticities, Production, Consumption, Econometric models.

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Introduction

In Mexico, poultry farming is the most dynamic livestock production activity. Production and consumption are growing steadily, production and distribution systems are more integrated than in other livestock sectors[1], and it is the principal means of transforming vegetable protein into animal protein[2]. Chicken meat is clearly the preferred animal protein source among Mexican consumers[3].

Domestic chicken meat production grew from 1.26 million tons in 1996 to 3.07 million tons in 2016, a 4.55 % average annual growth rate (AAGR). During this period, apparent national consumption increased from 1.39 to 3.84 million tons, at a 5.21 % average annual increase. Indeed, growth in consumption outstripped that in production. The difference between them was covered by imports, which increased by a 7.66 % annual average and, during this period, represented approximately 18 % of chicken meat consumption[3].

This dynamism in poultry production has exhibited disparities between regions over time. For example, in 2016 producers in Mexico’s Central-West (CW) and Central-Eastern (CE) regions achieved strong economic growth, contributing a cumulative 53.37 % to national production, whereas, even when taken together, the Northeast (NE) and Yucatan Peninsula (PE) regions contributed only 7.76 %[4].

During this period, the price of chicken carcasses varied between regions. For example, in 2016 the price per kilogram ($/kg) in the CW region, that with the highest chicken meat production, was $30.53 pesos per kilogram, which was 3.38% lower than the previous year. This decline in production costs responded to improvements in production conditions, control of avian influenza, and decreases in the international prices of the main fodder grains[5]. During the same period prices varied from $29.68 / kg in the CE region, to $32.22 / kg in the PE region and $33.37 / kg in the East (ET)[4].

Sorghum, the principal component of chicken feed[6], also varied widely in price between regions during 2016. For example, compared to 2015 the price of sorghum increased by 10.13 % in the NE, 8.41 % in the North (NT) and 2.84 % in the CE, but decreased by 2.84 % in the PE[4].

Demand by region varied from 1996 to 2016, from 5.15 % AAGR in the CE to 4.95 % in the CW and 4.98 % in the South (ST). In part this behavior can be explained by increases in per capita gross domestic product (GDP) (2.67 % in CE; 4.35 % in CW; and 3.27 % in ST)[7], population growth (1.17 % in CE; 0.99 % in CW; and 1.02 % in ST)[8], consumer preference, number of household members, and income. All these factors positively affect meat consumption probability[9].

Interregional differences in the dynamics of the different economic and technological variables that determine chicken meat supply and demand clearly exist. Econometric models are therefore needed to represent how different regional markets operate, and to generate tools that help guide public policy makers and provide alternatives for designing production support programs based on regional needs.

Chicken meat supply and demand is apparently affected by regional variation in the variables that influence it. The present study objective was to quantify the effect of the main economic and technological variables that influence chicken meat supply and demand in eight regions in Mexico (Northwest, North, Northeast, Central West, Central East, South, East and Yucatan Peninsula) from 1996 to 2016.

Material and methods

Regionalization is a methodology, procedure or intervention applied to reorganize a country into smaller territorial units with common characteristics. It is a basic methodological tool in environmental planning since it provides knowledge of regional resources for appropriate management[10]. Using this approach Mexico has been divided into eight economic regions to analyze chicken meat supply and demand at the regional level[11] (Table 1).

Table 1: Regions of Mexico and the states within them

Region	**States**
Northwest (NW)	Baja California, Baja California Sur, Sonora, Sinaloa and Nayarit
North (NT)	Chihuahua, Coahuila, Durango San Luis Potosí and Zacatecas
Northeast (NE)	Nuevo León and Tamaulipas
Central-West (CW)	Aguascalientes, Colima, Guanajuato, Jalisco and Michoacán
Central-East (CE)	Mexico City, Hidalgo, Estado de México, Morelos, Puebla, Querétaro and Tlaxcala
South (ST)	Chiapas, Guerrero and Oaxaca
East (ET)	Tabasco and Veracruz
Yucatan Peninsula (PE)	Campeche, Quintana Roo and Yucatán

A multiple linear regression econometric model was developed for chicken carcass supply and demand in each of the regions from 1996 to 2016. Supply variables included: the price of chicken meat; technology (measured as feed efficiency); and input costs (i.e. feed price)[12]. Demand variables were the price of chicken meat; financial income; population; and the prices of substitute or additive products[13]. The models represent each regional market's internal behavior.

The data for each variable was obtained from sources such as the Agrifood and Fisheries Information Service (Servicio de Información Agroalimentaria y Pesquera - SIAP), the Agricultural Trusts (Fideicomisos Instituidos en Relación con la Agricultura -FIRA), the National Institute of Statistics, Geography and Data Processing (Instituto Nacional de Estadística, Geografía e Informática - INEGI), the National Council on Population (Consejo Nacional de Población - CONAPO) and the National Market Data and Integration System (Sistema Nacional de Información e Integración de Mercados - SNIIM). Feed efficiency (FE) was taken from previous reports for 1996 and 2016 [14], and data for the intervening years estimated with the annual average growth formula: $r = (D_f / D_i)^{1/n} - 1$; where D_f is final FE data, D_i is initial FE data, and r is average annual growth rate (AAGR).

Parameters in the linear models associated with the supply and demand function were estimated with the ordinary least squares (OLS) method[15]. This helped to identify the effect of each of the independent variables on the dependent variable, as well as generate the best unbiased linear and minimum variance estimators. These analyses were run with the SAS statistical package[16].

Statistical congruence of the supply and demand models was determined with the coefficient of determination (R^2). Calculation of the statistical significance of each equation was done with the F test, and that for the individual significance of each coefficient with the Student t test. Economic evaluation was done considering the signs and magnitude of the coefficients of the variables of the supply and demand functions. These were interpreted using the fundamentals of economic theory. In other words, the relationship between chicken carcass supply and price with feed efficiency must be direct, whereas that with the price of pork and feed must be inverse. The relationship between chicken carcass demand and current price must be inverse, while it must be direct with respect to per capita GDP, current price of beef and human population.

In some regions, the variables of chicken meat price, pork (alternative good) price and feed price lagged one to two years behind other regions. Producers in these regions did not immediately decrease production in response to changing prices. Other factors also contributed to this lag such as interregional differences in length of the animal production cycle, degree of investment, production volume and company financial situation.

Calculations were done of the economic elasticities of each explanatory variable affecting chicken meat supply and demand in each region. These were evaluated based on the sign and magnitude of their coefficients, and interpreted following economic theory.

Five econometric models were proposed to calculate chicken meat supply and demand in the eight regional markets:

$CMS_t = \beta_{11} + \beta_{12}\,CMRP_t + \beta_{13}\,PRP_{t-2} + \beta_{14}\,RFP_t + \beta_{15}\,FE_t + £_t$ (NW and NT)
$CMS_t = \beta_{21} + \beta_{22}\,CMRP_t + \beta_{23}\,PRP_t + \beta_{24}\,RFP_t + \beta_{25}\,FE_t + £_t$ (NE, CW and CE)
$CMS_t = \beta_{31} + \beta_{32}\,CMRP_{t-1} + \beta_{33}\,PRP_{t-2} + \beta_{34}\,RFP_t + \beta_{35}\,FE_t + £_t$ (ST and ET)
$CMS_t = \beta_{41} + \beta_{42}\,CMRP_t + \beta_{43}\,PRP_{t-2} + \beta_{44}\,RFP_{t-2} + \beta_{45}\,FE_t + £_t$ (PE)
$CMD_t = \beta_{51} + \beta_{52}\,CMRP_t + \beta_{53}\,RGDP_t + \beta_{54}\,BRP_t + \beta_{55}\,POP_t + £_t$

Where:
CMS_t): chicken meat (carcass) supply in current period, estimated based on regional chicken carcass production (t);
$CMRP_t$: average real weighted regional price of chicken carcass, in current period ($/kg);
$CMRP_{t-1}$: average real weighted regional price of chicken carcass, with a one-year lag ($/kg);
PRP_t: average real weighted regional price of pork, in current period ($/kg);
PRP_{t-2}: average real weighted regional price of pork, with a two-year lag, as alternative product ($/kg);
RFP_t: average real weighted regional price of chicken feed, in current period, estimated based on price of sorghum as main ingredient ($/kg);
RFP_{t-2}: average real weighted regional price of chicken feed, with a two-year lag, estimated based on price of sorghum as main ingredient ($/kg);
FE_t: feed efficiency;
CMD_t: volume of chicken carcass demand, in current period, estimated based on apparent regional consumption (thousands of tons);

$RGDP_t$: real regional per capita gross domestic product, current period (thousands of \$/person), as a variable for approximating national per capita available income;
BRP_t: average real weighted regional price of beef (\$/kg), as substitute product;
POP_t: regional population, current period (millions of inhabitants/region).
All monetary variables were deflated based on the National Consumer Price Index (Índice Nacional del Precio al Consumidor – INPC; 2012 baseline = 100).

Model formulation was based on economic theory and empirical evidence. Chicken meat producers in Mexico base decisions on increasing, maintaining or decreasing production, on the price of chicken, the prices of the inputs needed to produce it and alternative products such as pork(17,18).

Feed efficiency (FE) was used to reflect technological progress in chicken meat production volume since it is one of the variables that most influence production in the poultry sector. It is also a factor that has stimulated increased chicken meat production in different regions of Mexico through genetic selection to produce chickens that generate more meat with the same amount of feed. Poultry farmers can thus continue to supply their product supported by increased productivity(6).

The FE variable integrates technological advances and helps to explain why poultry farmers continue to supply their product in the market, despite a clear downward trend in the price of chicken meat and price increases in sorghum, the main feed input(6). The price of pork as an alternative good was included because some companies produce both chicken and pork(19,20,21), using the same feed inputs(17,22).

Chicken meat and pork prices were calculated using the average real weighted regional price of the product in carcass form. Feed price was considered to be the price of sorghum since it is the main ingredient in both chicken and pig feed(6). All prices were calculated from the weighted average of all the states within each of the eight regions.

Regional chicken meat demand was calculated by considering apparent regional consumption as a variable approximating regional demand. Regional consumption was estimated based on production, plus imports and minus exports, within each region. The result was then multiplied by each region's population in a given year of the analyzed time series.

Based on economic theory, demand determinants included in the model included average real weighted regional price of chicken carcass [$CMRP_t$]); income (real regional per capita gross domestic product [$RGDP_t$]); price of substitute good (average weighted real regional price of beef [BRP_t]) and regional population (POP_t). All variables were calculated in the current period(12,13).

Elasticity values for each explanatory variable by region were calculated by multiplying the coefficients of the partial derivatives of the regional equations by the final observed value of each independent variable given the quantities for supply and demand. Since the supply and demand linear functions contain variable elasticity throughout their range of estimation, elasticity was calculated for the final year of the analyzed period, which is closest to the present[23]. The effects established in the functional relationships were quantified in this way.

Results and discussion

In most of the regions the chicken carcass supply equations exhibited a high coefficient of determination, the highest value being in the CW (R^2 = 98) and the lowest in the NE (R^2 = 65) (Tables 2 and 3). In the demand models, the regional coefficients of determination ranged from 0.98 to 0.99. The NW, NT, NE, CE and PE regions exhibited the best fit to the data. The supply and demand model was significant (*P*<0.05) according to the Fisher's F test.

Table 2: Estimated coefficients of determination for regional chicken carcass supply in Mexico, 1996-2016

Region	Dependent Variable	Intercept	Explanatory Variables				R^2	Prob>F
NW	CMS_t		$CMRP_t$	PRP_{t-2}	RFP_t	FE_t	0.97	0.0001
	Coefficient	-283.530	0.018	-0.084	-3.023	0.696		
	SE	80.766	7.594	1.474	4.555	0.193		
	t	-3.511	0.002	-0.057	-0.664	3.602		
NT	CMS_t		$CMRP_t$	PRP_{t-2}	RFP_t	FE_t	0.97	0.0001
	Coefficient	-429.039	5.467	-2.241	-41.770	1.315		
	SE	119.379	16.808	2.725	14.331	0.482		
	t	-3.594	0.325	-0.823	-2.915	2.728		
NE	CMS_t		$CMRP_t$	PRP_t	RFP_t	FE_t	0.65	0.0024
	Coefficient	-498.555	17.329	-4.062	-15.540	0.559		
	SE	374.659	9.015	1.230	5.862	0.255		
	t	-1.331	1.922	-3.301	-2.651	2.191		
CW	CMS_t		$CMRP_t$	PRP_t	RFP_t	FE_t	0.98	0.0001
	Coefficient	-859.623	25.465	-1.955	-2.452	1.449		
	SE	219.764	18.368	2.105	15.680	0.475		
	t	-3.912	1.386	-0.929	-0.156	3.054		
CE	CMS_t		$CMRP_t$	PRP_t	RFP_t	FE_t		
	Coefficient	-174.121	36.242	-3.750	-34.724	0.026	0.96	0.0001
	SE	173.069	11.621	1.192	10.502	0.252		

	t	-1.006	3.119	-3.146	-3.306	0.102		
ST	CMS_t		$CMRP_t$	PRP_{t-2}	RFP_t	FE_t	0.97	0.0001
	Coefficient	-255.419	0.595	-0.142	-3.699	0.598		
	SE	56.058	7.348	0.911	8.832	0.303		
	t	-4.556	0.081	-0.156	-0.419	1.975		
ET	CMS_t		$CMRP_t$	PRP_{t-2}	RFP_t	FE_t	0.89	0.0001
	Coefficient	-69.288	1.798	-5.019	-11.709	0.759		
	SE	144.104	10.379	3.787	13.598	0.501		
	t	-0.481	0.173	-1.325	-0.861	1.515		
PE	CMS_t		$CMRP_t$	PRP_{t-2}	RFP_{t-2}	FE_t		
	Coefficient	-44.205	8.873	-2.421	-0.218	0.019	0.94	0.0001
	SE	18.465	5.491	0.644	3.957	0.210		
	t	-2.394	1.616	-3.759	-0.055	0.090		

SE = Standard error; CMS_t: chicken carcass supply in current period; $CMRP_t$: average real weighted regional price of chicken carcass, in current period; $CMRP_{t-1}$: average real weighted regional price of chicken carcass, with a one-year lag; PRP_t: average real weighted regional price of pork, in current period; PRP_{t-2}: average real weighted regional price of pork, with a two-year lag; RFP_t: average real weighted regional price of chicken feed, in current period; RFP_{t-2}: average real weighted regional price of chicken feed, with a two-year lag; FE_t = feed efficiency.

Table 3: Estimated coefficients of determination for regional chicken carcass demand in Mexico, 1996-2016

Region	Dependent Variable	Intercept	Explanatory Variables				R^2	Prob>F
NW	CMD_t		$CMRP_t$	$RGDP_t$	BRP_t	POP_t	0.99	0.0001
	Coefficient	-323.601	-2.783	0.192	0.424	61.174		
	SE	14.927	0.842	0.183	0.296	3.615		
	t	-21.679	-3.304	1.045	1.433	16.923		
NT	CMD_t		$CMRP_t$	$RGDP_t$	BRP_t	POP_t	0.99	0.0001
	Coefficient	-496.889	-3.278	0.826	0.350	66.127		
	SE	64.500	0.835	0.423	0.373	9.670		
	t	-7.704	-3.926	1.955	0.937	6.838		
NE	CMD_t		$CMRP_t$	$RGDP_t$	BRP_t	POP_t	0.99	0.0001
	Coefficient	-251.052	-1.161	0.304	0.353	54.096		
	SE	13.831	0.358	0.072	0.125	2.934		
	t	-18.152	-3.247	4.250	2.828	18.440		
CW	CMD_t		$CMRP_t$	$RGDP_t$	BRP_t	POP_t	0.98	0.0001
	Coefficient	-722.606	-7.026	1.872	0.071	64.197		
	SE	114.992	2.109	0.516	0.536	10.298		
	t	-6.284	-3.331	3.629	0.133	6.234		

CE	CMD_t		$CMRP_t$	$RGDP_t$	BRP_t	POP_t		
	Coefficient	-1538.963	-5.887	4.901	0.297	55.572	0.99	0.0001
	SE	136.262	3.515	1.223	1.486	8.610		
	t	-11.294	-1.675	4.009	0.200	6.455		
ST	CMD_t		$CMRP_t$	$RGDP_t$	BRP_t	POP_t	0.98	0.0001
	Coefficient	-614.336	-1.525	1.906	0.001	72.960		
	SE	60.190	0.702	0.506	0.453	7.604		
	t	-10.207	-2.174	3.765	0.001	9.595		
ET	CMD_t		$CMRP_t$	$RGDP_t$	BRP_t	POP_t	0.98	0.0001
	Coefficient	-671.124	-3.195	0.430	0.011	98.815		
	SE	64.780	0.475	0.119	0.331	8.462		
	t	-10.360	-6.729	3.610	0.033	11.678		
PE	CMD_t		$CMRP_t$	$RGDP_t$	BRP_t	POP_t		
	Coefficient	-96.599	-0.444	0.102	0.000	49.720	0.99	0.0001
	SE	20.881	0.133	0.099	0.050	8.560		
	t	-4.626	-3.332	1.024	0.003	5.808		

SE = Standard error; CMD_t: volume of chicken carcass demand, in current period; $CMRP_t$: average real weighted regional price of chicken carcass, in current period; $RGDP_t$: real regional per capita gross domestic product, current period; BRP_t: average real weighted regional price of beef; POP_t: regional population, current period.

The contribution of each of the explanatory variables in both models was evaluated according to their asymptotic t or t-ratio. This must be greater than the unit since this indicates that the estimated parameter's value is greater than its standard error[24]. Not all the supply variables were significant in all the regions when using this parameter. The coefficient of the feed efficiency variables was significant in most regions, except the CE and PE. However, the coefficient of the chicken meat price variables was significant only in the NE, CW, CE and PE, but not in the NW, NT, ST and ET. Likewise, the coefficient of the pork price variable was significant in the NE, CE, ET and PE, but not in the NW, NT, CW and ST. In the demand models, the coefficients for chicken meat price, per capita GDP and population were significant (P<0.05) for all eight regions. In contrast, the beef price variable was significant only in the NW and NE, but not in the remaining six regions. Using Klein's practical rule[25], the present results indicate there to be no multicollinearity between the explanatory variables in the regional supply and demand models.

Regional elasticities

Coefficients of elasticity were determined by region to measure the magnitude of the dependent variable in response to variations (*ceteris paribus*) for each explanatory variable in the supply and demand models (Table 4). The magnitudes of supply and demand elasticities considering each independent variable were different in each of the regions; that is, the effect that these produced on chicken meat production varied between them. In most of the regions chicken meat supply was explained directly and elastically by technology (FE), although in the CE and PE this relationship was direct and inelastic. In contrast, chicken meat price was directly and inelastically related for chicken meat price in the NW, NT, CW, ST and ET, but direct and elastic in the NE, CE and PE. For most of the regions this relationship was inverse and inelastic for pork price and feed price, but in the NE it was inverse and elastic.

Table 4: Regional elasticities in supply and demand of chicken carcasses in Mexico, 1996- 2016.

	Regions							
Elasticity	**NW**	**NT**	**NE**	**CW**	**CE**	**ST**	**ET**	**PE**
Supply								
$CMRP_t$	0.0021	0.2824	3.6332	0.8125	1.5794	-	-	1.7069
$CMRP_{t-1}$	-	-	-	-	-	0.0941	0.1616	-
PRP_t	-	-	-1.4563	-0.0913	-0.2024	-	-	-
PRP_{t-2}	-0.0110	-0.1615	-	-	-	-0.0253	-0.4738	-0.5273
RFP_t	-0.0325	-0.1899	-0.4256	-0.0084	-0.1436	-0.0475	-0.0876	-
RFP_{t-2}	-	-	-	-	-	-	-	-0.0034
FE_t	2.2151	1.8561	4.6830	1.2548	0.0299	2.2015	1.5884	0.0872
Demand								
$CMRP_t$	-0.2101	-0.2127	-0.1037	-0.2767	-0.1196	-0.1014	-0.2525	-0.0819
$RGDP_t$	0.0741	0.2844	0.2159	0.3557	0.5457	0.2763	0.1428	0.1536
BRP_t	0.0656	0.0506	0.0817	0.0063	0.0122	0.0001	0.0017	0.0001
POP_t	1.9750	2.1045	1.7184	2.0220	1.7868	2.3610	3.1295	1.5855

$CMRP_t$: average real weighted regional price of chicken carcass, in current period; $CMRP_{t-1}$: average real weighted regional price of chicken carcass, with a one-year lag; PRP_t: average real weighted regional price of pork, in current period; PRP_{t-2}: average real weighted regional price of pork, with a two-year lag; RFP_t: average real weighted regional price of chicken feed, in current period; RFP_{t-2}: average real weighted regional price of chicken feed, with a two-year lag; FE_t = Feed efficiency; $RGDP_t$: real regional per capita gross domestic product, current period; BRP_t: average real weighted regional price of beef; POP_t: regional population, current period.

The increases recorded in chicken meat production volume in most regions were due to technological change, defined as feed efficiency (FE). This variable exhibited greater elasticities than the others, especially in the NE (4.683), NW (2.215) and ST (2.201), and somewhat lower elasticities in the NT (1.856), ET (1.588) and CW (1.255). Elasticities were below the threshold in the CE (0.030) and PE (0.087), which translates into inelastic response to technological change. These discrepancies in elasticities were caused by interregional variations in input and chicken meat prices.

Greater technology use in poultry production lowers production costs and improves productivity[6]. For example, if technology use were to increase by 10 % it would cause the chicken carcass supply curve to shift to the right. This would represent production increases of 46.83 % in the NE, 22.21 % in the NW and 22.01 % in the ST. In terms of volume, this would mean raising output (in 2016 terms) from 82,570 to 121,230 t in the NE, from 193,730 to 236,750 t in the NW, and from 190,050 to 231,880 t in the ST. This behavior is consistent with data from 1970-1998[6], during which the elasticity value for technological change related to chicken meat supply in Mexico was 1.972.

Chicken meat supply related to product price at current prices ($CMRP_t$) and with a one-year lag ($CMRP_{t-1}$) responded elastically in the NE (3.633), CE (1.579) and PE (1.707). This indicates that in response to a one percent rise in the price of chicken meat, the quantity supplied increased by more than one percent in these three regions. In the remaining five regions, this relationship behaved inelastically (NW, 0.002; NT, 0.282; CW, 0.813; ST, 0.094; ET, 0.162), meaning that a one percent rise in the price of chicken meat resulted in not significant increases in supply in these regions. These findings coincide with previous reports of inelastic values for chicken meat supply in relation to price[13,26,27].

Chicken meat supply in response to changes in the price of pork (as an alternative product) at the current price (PRP_t), and with a two-year lag (PRP_{t-2}), was inelastic in all regions except the NE, where it was elastic. Under this scenario in the NE region, increases in pork prices caused producers of chicken meat and pork to increase pork production, which could in turn negatively affect chicken meat supply in the region. This response was not significant in the other regions.

Chicken meat supply related to changes in feed price at the current price (RFP_t), and with a two-year lag (RFP_{t-2}) differed between regions. Coefficient magnitude was less inelastic in the NE (-.0144) and NT (-0.190) than in the remaining regions. In other words, chicken meat production volume in the NE and NT responded inversely and more noticeably to variations in feed price. The CW and PE regions were more inelastic (-0.008, -0.003, respectively) than all the other regions; that is, in response to a one percent increase in feed price (RFP_t, RFP_{t-2}), chicken meat supply decreased at not significant levels. The coefficient values for the NE and NT were near the -0.164 reported for chicken meat supply in response to the expected price of sorghum (the main ingredient in chicken feed) from 1978-1998 in Mexico[6]. Although the magnitude of elasticity may vary between studies from different periods the inelastic nature of this relationship is apparently constant.

In terms of elasticities of demand, the variable that most affected chicken meat consumption in all the regions was population size, since its behavior was elastic in all of them. The highest elasticities were in the ET (3.1295), ST (2.3610) and NT (2.1045), which represent significant increases in chicken meat consumption given a one percent change in population size. Increases in demand were slightly lower in the CW (2.0220), NW (1.9750) and CE (1.7868). The overall effect of population size on increased chicken meat consumption in the different regions may be explained by Mexico's 1.22% average annual population growth during the study period. These results agree with a study in which the behavior of regional supply and demand of pork in Mexico responded elastically in all regions to growth in human population(23).

The elasticity of chicken meat demand related to its current price was inelastic in all the regions, although values varied. They were less inelastic in the PE (-0.0819), ST (-0.1014) and NE (-0.1037). This economic variable had a lesser effect on chicken meat consumption in these regions, probably due to differences in per capita income and substitute product price between the regions. Previous studies have also found inelastic profiles in this relationship (e.g. -0.36, -0.4718, 1.191, -0.2148, -0.1695)(26-29), which differ slightly from the present values because they are from different periods.

For chicken meat demand in relation to per capita gross domestic product ($RGDP_t$) all the regions exhibited some degree of elasticity. The lowest coefficients were in the NW (0.0741), ET (0.1428) and PE (0.1536), and the highest were in the CE (0.5458), CW (0.3557) and NT (0.2844). These higher values indicate chicken meat consumption was explained to a greater extent by increased $RGDP_t$ in these regions. Overall elasticity for this relationship (based on available real per capita income) in Mexico from 1970-1998 was 0.3347(6).

Elasticity of chicken meat demand in response to the price of beef (BRP_t) varied widely between regions. It was highest in the NE (0.0817), NW (0.0656) and NT (0.0506), and lowest in the ST (0.0001), PE (0.0001) and ET (0.0017). These values indicate that increases in the price of beef had minimal effects on chicken meat demand.

Conclusions and implications

Technological progress (defined as feed efficiency) was the factor that most influenced growth in poultry production in most of the regions in Mexico. Regional demand for chicken meat was elastic in relation to population growth; that is, in all the regions increases in population had the largest influence on increases in chicken meat consumption. The present results explain to what extent the evaluated explanatory variables affect regional supply and demand of chicken meat in Mexico.

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