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The Steel Market in Mexico: 1980-2015

***Eugenio Guzmán-Soria*[1], *María Teresa de la Garza-Carranza*[2], *José Alberto García-Salazar*[3], *Samuel Rebollar-Rebollar*[4], *Juvencio Hernández-Martínez*[5]**

[1,2]Departamento de Ciencias Económico Administrativas, Instituto Tecnológico de Celaya-Campus II, Av. García Cubas 1200, Esquina Ignacio Borunda, Celaya, Guanajuato, México.
[3]Instituto de Socieconomía, Estadística e Informática. Programa de Economía. Km 26.5 Carr. México-Texcoco. Montecillo, Estado de México, México.
[4]Facultad de Medicina Veterinaria y Zootecnia, Centro Universitario UAEM Temascaltepec-Universidad Autónoma del Estado de México, Barrio de Santiago s/n, Temascaltepec, Estado de México, México.
[5]Programa de la Licenciatura en Economía, Centro Universitario UAEM Texcoco-Universidad Autónoma del Estado de México, Av. Jardín Zumpango s/n, Fracc. El Tejocote Texcoco, Estado de México, México.

Abstract: In 2015, world steel production was 1,620.4 million tons; China is the main producer (49%), followed by Japan (0.06%). World exports are concentrated in China and Japan with 33%, Mexico imported 17% of those made by North America; what impacts on the internal dynamics of the steel market. To determine the effect of the change in the main factors that explain the Mexican steel market; as well as quantifying the level of impact of the international price of this commodity on the steel wholesale price in Mexico, a model of simultaneous equations was estimated with annual information from 1980 to 2015; composed of 5 regression equations and an identity. The results indicate that in the short term steel consumption and production in Mexico responds inelastic (-0.1284%) and elastically (2.3863%) before changes of 1% in the corresponding prices. The changes in the price of the factors that most affect consumption are the urbanization process, the national income per capita and the price of housing with price-cross elasticities of 0.4843, 0.4544 and 0.3762; and to production are the electricity tariff and the price of oxygen to produce steel with cross-price elasticities of -4.0917 and -1.6371. The effect of the international price of steel and the cost of transport in Mexico, affect the wholesale price at a level of 0.05 and 1.05%, for each unit percentage.

Keywords: Steel, consumption, production, simultaneous equations, elasticities.

I. INTRODUCTION

In March 2016, world gross steel production registered a volume of 137 million tons (Mt), reflecting a decrease of -0.5% compared to the same month of 2015, according to the World Steel Association (WSA), from a total of 66 countries. During the first quarter, steel production in the world reached a volume of 385.7 Mt, 3.6% less than the same period last year. The decline also occurred in Asia which, with a production of 263.6 Mt, registered a fall of -3.1%. It also fell in the European Union (EU), a region that achieved steel production of 40.9 Mt in that period (-7%) and in North America, where production was 27.5 Mt in the same quarter (-1.1%) (Metals and Metallurgy, 2016).

Despite these declines, steel production in China recovered in March 2016, when it registered a volume of 70.7 Mt, 2.9% more than in March 2015. In other parts of Asia, however, Japan played a leading role a fall of -6.8% with 8.6 Mt

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produced. In the case of India, steel production increased by 3.4%, registering a volume of 8.1 Mt. In the case of the EU, the behavior of crude steel production was negative, compared to the same month last year. Germany produced 3.8 Mt (-1.6%); Italy registered a volume of 2 Mt (-3.5%); and France had a production of 1.1 Mt (-21.4%). Turkey, on the other hand, recorded a new increase in steel production in March (+ 1.3%), with a volume of 2.7 Mt.

As for Russia, the country produced 6 Mt of steel in March, which represents a decrease of -2% with respect to the same month of 2015. Ukraine registered an increase in production of 28.1%, with 2.2 Mt of steel produced in the month of March. The United States produced 6.7 Mt of steel in March of this year, a figure that represents an increase of 4.9% compared to the same month of 2015. In the case of Brazil, production decreased by -9.5%, with 2.5 Mt in March (Metals and Metallurgy, 2016).

In 2015, world steel production was 1,620.4 Mt, which represented a decrease of 3% compared to 2014 and 2% lower compared to 2013. By continent, Asia produced 1,112.9 Mt of steel, a decrease of 2.4 % with respect to 2014. Highlighting the production of China, which was 803.8 Mt, 2.3% lower compared to 2014. Japan produced 105.1 Mt of steel, decreased by 5% compared to the previous year. South Korea produced 69.7 Mt, 2.5% less than in 2014. The European Union (EU) produced 166.1 Mt of steel, which represented a decrease of 1.9% compared to 2014. Germany produced 42.7 Mt, which represented a reduction of 0.5% compared to the previous year; while Italy's production was 22 Mt, which is equivalent to 7.2% increase compared to the same month of the previous year. Spain produced 14.8 Mt of steel, increased by 4.2% compared to 2014. Outside the European Union, it stands out Turkey's steel production which in 2015 was 31.5 Mt, which registered an increase of 7.4% compared to 2014 (WSA, 2016).

In Africa, steel production in Egypt stood out, which in 2015 was 5.5 Mt, which represented a decrease of 15.4% compared to 2014. Steel production in North and Central America (Canada, Cuba, El Salvador, Guatemala, Trinidad and Tobago, Mexico and the United States) was 110.9 Mt, 8.3% lower than in 2014. The United States produced 78.8 Mt, Canada 12.5 Mt and Mexico 18.2 Mt; which represented 3.7% less than in 2014. South America produced 43.9 Mt during 2015, 2.4% less than in 2014; highlighting the productions of Brazil and Argentina with 33.3 and 5 Mt, respectively.

In 2015, steel exports were 462.4 Mt; Asia exported a total of 212.1 Mt, which represented 46% of exports worldwide. The three most representative exporting countries in the Asian continent were: China with 111.6 Mt (53%), Japan 40.8 Mt (19%), and South Korea with 31.2 Mt (15%). The European Union exported a total of 140 Mt, which represented 30.3% of exports worldwide. The three countries with the largest share of European exports were: Germany (25.1 Mt), Italy (16.5 Mt), Belgium (15.2 Mt), France (14 Mt) and Holland (10.6 Mt). In Africa, the export of steel from South Africa stood out, which for 2015 was 2.2 Mt. In the Americas, steel exports during 2015 behaved as follows: In North America, exports amounted to 20.1 Mt, which represented 4.3% of world exports, being the three most representative exporters of this region: the United States with a participation of 10 Mt, Canada with 6 Mt, and Mexico with 3.4 Mt. With respect to South America, the export was 14.6 Mt representing 3.2% of world exports; Brazil being the largest exporter with 13.7 Mt (WSA, 2016).

Regarding steel imports, in 2015, they added up to a total of 453.5 Mt. Asia imported a total of 141.5 Mt, which represented 31.2% of the total

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worldwide. The three most representative importing countries in the continent were: South Korea (21.7 Mt), Vietnam (16.3 Mt), Thailand (14.6 Mt), India (13.3 Mt), China (13.2 Mt) and Indonesia (11.4 Mt). The European Union imported a total of 139.8 Mt, which represented 30.8% of world imports; the three countries with the highest participation were: Germany (24.8 Mt), Italy (19.9 Mt), France (13.7 Mt) and Belgium (12.1 Mt). Africa imported 31.1 Mt, which represented 6.9% of the total imports in the world; the imports from Egypt (7.9 Mt), Algeria (6.3 Mt), and Morocco (2 Mt) stand out.

In the American continent imports of steel behaved as follows: North America imported 59.1 Mt, which represented 13% of world totals, being the three most representative importers: the United States (36.5 Mt), Mexico (10 Mt) and Canada (8 Mt). In South America, the import of steel was 14.2 Mt, representing 3.1% of the world import; in this region, imports from Brazil (3.2 Mt), Colombia (2.9 Mt), Peru (2.2 Mt), Chile (1.9 Mt), Argentina (1.2 Mt) and Ecuador (1 Mt) stick out (WSA, 2016).

During 2011, Mexico ranked 13th as an international steel producer, accounting for 1.2% of world production of 1,412.8 Mt. As regards Latin America, steel production was 61.7 Mt and Mexico ranked second place after Brazil (32.92 Mt), which in sum represented 27.1% of the total production in the region (SE, 2012). In December 2016, with seasonally adjusted figures, mining-metallurgical production in Mexico decreased by 4.7% with respect to the previous month. In an annual comparison, this production observed a real decrease of 6.3% in the same month of 2016 with respect to the previous year; this decrease was the result of the heterogeneous behavior among the different minerals that make up the mining-metallurgical production, the gypsum, carbon, lead, sulfur, zinc, silver, gold and fluorite mainly went down. In contrast, iron, copper and dolomite pellets were only marginally increased (INEGI, 2017).

In 2011, Mexico had an installed capacity for steel production of 22,227 Mt per year and only used 75.18% of it. Its total steel production was 16.71 Mt and the main producing states were: Coahuila (28.8%), Michoacán (23.6%), Nuevo León (15.5%), Guanajuato (10.8%), Veracruz (7.6%), and the the rest of the entities concentrated 17.6%. The participation of the steel industry in the domestic Gross Domestic Product (GDP) represented 0.7% of the total GDP, 7.9% of the GDP of the industrial sector and 3.9% of the manufacturing sector. Exports of Mexican steel in 2011 amounted to 5.9 Mt; which in value translated into 5,079 million dollars (MDD) and the amount of imported steel was 7.1 Mt, which equaled 7,986 MDD. This meant a trade deficit, in terms of steel, of 1.2 Mt (2,907 MDD) (SE, 2012). In addition to the above, in 2008 the National Chamber of the Iron and Steel Industry (Cámara Nacional de la Industria del Hierro y del Acero-CANACERO) and the Ministry of Economy (Secretaría de Economía-SE) presented the development of a strategic action plan for the steel sector in Mexico, which includes the following: A) The CANACERO together with the SE have defined a growth plan with the objective of doubling the GDP of the steel sector for 2020 from 6 thousand MDD to 12 thousand MDD, this represents an increase in national production from 17.8 to 32 Mt /year. In addition to the necessary support for integrated production chains with steel, the goal involves direct investments in installed capacity of US $ 19 billion, 30 thousand additional direct jobs and incremental tax collection for the government, over 400 MDD per year (CANACERO, 2008).

To achieve the proposed growth, CANACERO and SE specified that the steel sector should:

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capture the total inertial growth of the sector by 2020 (8.2 Mt), replace part of Mexico's imports (0.5 Mt), increase exports to the United States United (3.3 Mt). In addition to the inertial growth, it was expected to have important increases in several industries: Automotive industry (0.8 Mt/year), Oil industry (0.4 Mt/year), Construction industry related to the National Infrastructure Program (1 Mt/year). These growths will be achieved by focusing the sector's efforts on those products with the greatest attraction (high growth) and with the best competitive position in Mexico, for the domestic market: rod and rod, plate, hot rolled sheet and coated sheet, for the market Export: semi-finished, tubes and hot rolled sheet. To capture these opportunities, the steel sector has developed a strategic plan in the short and medium term. In the short term, the steel sector should promote actions through four main channels (CANACERO, 2008): 1) Competitiveness of costs, 2) Technological innovation, 3) Market development and 4) Attraction of investment: Development of an incentive program and a program to promote the investment of participants in the steel sector.

Additionally CANACERO (2008), indicates that it will monitor a set of actions of second priority: improvement in the supply of natural gas, reduction in the peak electricity supply period, development of the scrap market, among others. It is fundamental to structure an implementation team dedicated to follow up and implement each of these actions.

For the aforementioned, the objective in this work was the identification of the factors that influence both the supply and demand of the national steel, which in turn impact on the price to the producer, the consumer and the wholesale of steel. Mexican, highlighting the problems facing Mexico: 1) having registered an excess of demand in recent years, resulting in steel imports, given that domestic production does not satisfy domestic demand (in 2015 the figure for imported steel represented a 51.8% of national production) and, 2) development planning in the national steel sector without having indicators and estimates that contribute information for better decision making in the short and long term.

The research hypotheses were that: 1) The consumption of steel is determined, inversely by the price to the consumer and directly by income (variable proxy the Gross Domestic Product of the construction sector in Mexico) and by the process of urbanization; 2) The supply of steel is determined directly by the producer price of steel and inversely by the price of inputs (scrap, electric power and oxygen) and, 3) The prices to the consumer and the steel producer in Mexico is directly impacted by the wholesale price and the effect of the international (import) price on the latter is positive.

II. METHODOLOGY

The model

The simultaneous equation model used was composed of distributed lag models, in which to explain the response of the dependent variables (Y) to a unit change of the explanatory variables (X) not only were their current values considered, but also the laggards or previous

$$(1) \qquad Y_t = \alpha + \beta_0 X_t + \beta_1 X_{t-1} + \beta_2 X_{t-2} + U_t$$

and, autoregressive models and distributed lags; since lagged values of the dependent variable were included as explanatory

$$(2) \qquad Y_t = \lambda + \lambda_1 X_t + \lambda_2 X_{t-1} + \lambda_3 Y_{t-1} + \varepsilon_t$$

A system of simultaneous equations can be expressed in condensed matrix form as (Gujarati y Porter, 2009):

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(3) $\Gamma Y_t + BX_t = E_t$

where: Y_t = Vector of endogenous variables of the model; X_t = Vector of predetermined variables, plus the ordered to the origin; Γ = Matrix of structural parameters associated with endogenous variables; B = Matrix of structural parameters associated with the predetermined variables; E = Vector of random error terms. The vectors Y_t y E_t are of order *m x 1*, where *m* is the number of endogenous variables of the model. For its part, Γ is a square matrix of order *m x m*. At the same time, B it is a matrix of order *k+1 x m*, where *k* is the number of exogenous and endogenous delayed variables of the model plus the ordered one at the origin; in general, *k* it may or may not be equal to *m*. When there is the inverse of Γ, it is possible to derive the reduced model of the system:

(4) $Y_t = \Pi X_t + V_t$

where: $\Pi = -\Gamma^{-1}B$ is the matrix of the parameters of the reduced form; $V_t = -\Gamma^{-1}E_t$ is the matrix of the perturbations of the reduced form.

Based on the above, the relationship between the factors that explain the steel market in Mexico was determined by calculating the elasticities, via the results obtained from a simultaneous equations model composed of a consumption equation and a production equation, three Equations of transmission of prices and an identity. The econometric model of the steel market in the country in its structural form was formulated by adding functional ratios, structural coefficients or *α*'s, which represent the estimators of the parameters of each variable and the *ε*'s or the stochastic term:

(5)
$$CAM_t = \alpha_{11} + \alpha_{12}PACMR_t + \alpha_{13}PIBSCR2L_{t-2} + \alpha_{14}PVAM2L_{t-1} + \alpha_{15}IPVM_t + \alpha_{16}INBPRL_{t-1} + \alpha_{17}PU_t + \alpha_{18}CAML_{t-1} + \varepsilon_{1t}$$

(6) $$PACMR_t = \alpha_{21} + \alpha_{22}PAMMR_t + \alpha_{23}D_t + \varepsilon_{2t}$$

(7)
$$PAMMR_t = \alpha_{31} + \alpha_{32}CTAMR_t + \alpha_{33}PINTARL_{t-1} + \alpha_{34}D_t + \varepsilon_{3t}$$

(8)
$$PAPMR_t = \alpha_{41} + \alpha_{42}PAMMR_t + \alpha_{43}D_t + \varepsilon_{4t}$$

(9)
$$PAM_t = \alpha_{51} + \alpha_{52}PAPMRL_{t-1} + \alpha_{53}PCHPAR_t + \alpha_{54}PEEPARL_{t-1} + \alpha_{55}PO2PARL_{t-1} + \alpha_{56}PAML_{t-1} + \varepsilon_{5t}$$

(10) $$SCA_t = PAM_t - CAM_t$$

where: CAM_t = Amount of steel consumed in Mexico (t); $PACMR_t$ = Real price of steel to the consumer in Mexico ($/t); $PIBSCR2L_{t-2}$ = Gross domestic product of the construction sector in real Mexico with two years of lag ($); $PVAM2L_{t-2}$ = Production of automotive vehicles in Mexico with two years of lag (units); $IPVM_t$ = Index of the price of housing in Mexico (%); $INBPRL_{t-1}$ = Per capita gross national income in Mexico with one year of lag ($/habitant); PU_t = Urbanization process in Mexico [(urban population / rural population)*100] (%); $CAML_{t-1}$ = Amount of steel consumed in Mexico one year behind schedule (t); $PAMMR_t$ = Real steel wholesale price in Mexico ($/t); D_t = Classification variable (dummy) with zero from 1980 to 1986 representing the closed economy period, and one from 1987 to 2015 representing the open; $CTAMR_t$ = Cost of transporting steel in Mexico ($/t); $PINTARL_{t-1}$ = international price of steel with one year of lag-variable proxy the price of steel in China ($/t); PAM_t = Steel production in Mexico ($/t); $PAPMRL_{t-1}$ = Real steel price to producer in

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Mexico in year *t* with one year of lag ($/t); $PCHPAR_t$ = Scrap price in Mexico ($/t); $PEEPARL_{t-1}$ = Price of electric power to the steel producer in Mexico with one year of lag [HT high voltage rate 230 kV] ($/kWh); $PO2PARL_{t-1}$ = Price of oxygen to the steel producer in Mexico with one year of lag ($/m^3); $PAML_{t-1}$ = Steel production in Mexico with one year of lag ($/t); SCA_t = Balance of foreign trade of steel in Mexico.

The assumptions used to estimate the model were: a) The relationship between the endogenous and exogenous variables is linear; b) The endogenous variables are stochastic as well as the errors; c) The $E(\varepsilon_i\ \varepsilon_j) = 0$, $i \neq j$; d) The $E(\varepsilon_i\ \varepsilon_j) = \sigma^2$, has constant variance; e) The errors do not present serial correlation, that is, $E(\varepsilon_t\ \varepsilon_{t-1}) = 0$ and f) The endogenous variable SCA_t it is defined as an identity, therefore it does not contain stochastic disturbances.

For the aforementioned variables, time series were created with annual information for the period 1980-2015 and given that in the market, the response of supply or demand to the changes of its determining factors is rarely instantaneous, but frequently they respond after a certain time, a period that is called lag or delay (Gujarati and Porter, 2009). In the cited model, it was assumed that some of the exogenous variables are influenced by one and up to two lag periods; what was statistically justified in terms of its individual significance.

Equations 5 and 9 model the consumption and production of steel in the country. Equations 6 and 8 model the effect of transmission that the real price of wholesale steel in Mexico has on the real price of steel to the consumer and the producer. Equation 7 models the effect that the transport cost and the steel producer price in China have on the wholesale price in Mexico, since it is the main producing country; and finally the identity equation 10 establishes the trade balance in the country.

Data of the model variables

The amount consumed and steel production in Mexico were obtained from WSA (1980-2015); The consumer price of steel in Mexico, the steel producer in Mexico, the wholesale price of steel in Mexico, the cost of transporting steel in Mexico, the price of steel in China was used as a proxy variable of the international price of steel , the price of scrap in Mexico and the price of oxygen to the steel producer in Mexico were obtained from CANACERO (several years); The gross domestic product of the construction sector in Mexico, the gross national income in Mexico, the production of motor vehicles in Mexico and the housing price index in Mexico were obtained from INEGI-BIE (2017a); The information for the calculation of the urbanization process in Mexico was obtained from INEGI (2017); As the price of electricity to the steel producer in Mexico, the high voltage HT tariff 230 kV was used and it was obtained from CFE (several years).

The monetary series were deflated with: the National Consumer Price Index; the National Producer Price Index; the National Consumer Price Index for the Transport Sector and the Price Index Implicit in the Gross Domestic Product. The indices were obtained from INEGI-BIE (2017b).

Estimation method

The coefficients of the model were estimated with the two-stage least squares method (MC2E) (Wooldridge, 2009 and Gujarati and Porter, 2009) using the package Statistical Analysis System version 9.0 (SAS, 2002). Statistical congruence was determined by means of the overall significance of each equation through the F test, its level of self-correlation via the Durbin Watson statistic (DW), the individual significance of each

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coefficient through the Student's t and the normality of the variables with the Shapiro-Wilk test (SW). The microeconomic theory of production (Samuelson and Nordhaus, 2010) was used to validate the sign of the coefficients of each exogenous variable. To determine the identification of the model, the order and rank conditions based on Gujarati and Porter (2009) were used, obtaining that each of the equations of the model is overidentified.

The estimated coefficients y, the mean values of the time series were used to calculate the economic elasticities of each factor affecting the steel market at the national level. The short-term price elasticities (Ep, cp) at any point of the curve are given by (Gujarati and Porter, 2009):

(11) $Ep, cp = (\partial Q_t / \partial P_t)(P_t / Q_t) = b_1 (P_t / Q_t)$

where: $(\partial Q_t / \partial P_t)$, is the slope of the supply curve (b_1) y P_t y Q_t, they are the price received by the consumer or producer in year t and the quantity consumed or offered in year t, as the case may be.

To calculate the cross-elasticities with respect to the prices of related products and other market factors, the respective coefficients, price and quantity were used. To obtain the long-run elasticities, the respective coefficients of the long-term model were used, which were obtained by dividing the short-term coefficients between the adjustment speed coefficient (γ) and eliminating the lagged amount Q_{t-1}:

(12) $Q_t = (b_0 / \gamma) + (b_1 / \gamma) P_{t-1} + \upsilon_t$

then the own price elasticity of the long-term supply was obtained as,

(13) $Ep, lp = (\partial Q_t / \partial P_t)(P_t / Q_t) = (b_1/\gamma)(P_t / Q_t)$

The long-term cross-price elasticities for prices of related products and other market factors were calculated using the respective coefficients of the long-term model.

III. RESULT AND DISCUSSION

The five regression equations of the model in its structural form presented a high goodness of fit with adjusted coefficients of determination (R^2 *Ajust*) of 0.92 to 0.99, the value of the F test of each equation was significant at a level of 0.01, the DW statistic indicates the existence of a low level of autocorrelation between the time series (1.34 – 2.19) and the value of SW per variable ranged between 0.94 and 0.99; which implies that its distribution is close to normal (Table 1). The t-values indicate that all the coefficients of the explanatory variables of the model are statistically significant and also their signs presented congruence with the theory of production. The coefficients of the reduced form of the model with respect to SCA are presented in Table 2.

Table 1. Results of the model in its structural form.

CAM=5320053-*40.4209PACMR*+0.0000003236*PIBSCR2L*				
T	(2.10**)	(-1.25*)	(1.49**)	
Error sd.	2534196	32.42866	0.0000002175	
SW		0.92	0.94	
+22.2703PVAM2L+111836.2*IPVM*+*78.8252INBPRL*+18431.91*PU*				
t	(0.92*)	(2.53***)	(2.73***)	(1.56**)
Error sd.	24.19042	44276.96	28.86477	11823.33
SW	0.96	*0.93*	0.97	0.95
+0.358588*CAML*				
t	(2.29****)			

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Error sd.	0.156473			
SW	0.98			
R^2=0.94; R^2Ajust=0.92; Pr > F=0.0001; DW=2.19; BP[1]=1.83				
PACMR=18301.45+ 0.273094*PAMMR* -7316.08*D*				
t	(3.76***)	(26.6***)	(-1.49***)	
Error sd.	4865.416	0.010266	4921.31	
SW		0.94	0.93	
R^2=0.98; R^2Ajust=0.98; Pr > F=0.0001; DW=1.34; BP=1.69				
PAMMR=19977.74+6.21827*CTAMR*+0.6305*PINTARL-24303.8D*				
t	(2.26**)	(70.36***)	(2.22**)	(-3.35***)
Error sd.	8839.996	0.088381	0.284432	7257.934
SW		0.96	0.95	0.98
R^2=0.99; R^2Ajust=0.99; Pr > F=0.0001; DW=1.97; BP=1.79				
PAPMR = 10565.19+ 0.693524*PAMMR-8741.94D*				
t	(12.9***)	(401.43***)	(-10.56***)	
Error sd.	818.8077	0.001728	828.2142	
SW		0.99	0.96	
R^2=0.99; R^2Ajust=0.99; Pr > F=0.0001; DW=2.56; BP=1.89				
PAM= 1765413+293.3751*PAPMRL*+116.2469*PCHPAR*				
t	(1.88***)	(0.99**)	(0.79*)	
Error sd.	939531.4	296.3495	146.5646	
SW		0.95	0.98	
-849583*PEEPARL* - 42387.27*PO2PARL* + 0.850837*PAML*				
t	(-1.03**)	(-1.07**)	(9.41***)	
Error sd.	824591.6	39526.56	0.090457	
SW	0.93	0.94	0.97	
R^2=0.94; R^2Ajust=0.93; Pr > F=0.0001; DW=2.15; BP=1.88				

[1] Statistic Breush-Pagan (BP) as a test of heteroscedasticity between the time series.

Note: Statistical significance of the values t to the 0.1 (*); 0.05 (**); 0.01 (***).

Table 2. Coefficients of the reduced form of the model with respect to SCA.

Endogenous variables	Exogenous variables			
	Intercept	PACMR	PIBSCR2L	PVAM2L
SCA	-2594350	40.42090	-0.0000003236	-22.2703
	IPVM	INBPRL	PU	CAML
SCA	-111836.0	-78.82523	-18431.9	-0.35859
	PAPMRL	PCHPAR	PEEPARL	PO2PARL
SCA	293.3751	116.2469	-849583	-42387.27
	PAML	D	CTAMR	PINTARL
SCA	0.850837	-564006	68.64172	6.9604

Short and long term elasticities of the structural form

In the short term, the own price elasticities estimated in the structural form of the model indicate that steel production in Mexico responds elastically with 2.3863. This was higher than the one calculated by Giuliodori and Rodríguez (2015) for Germany, which was 1,318 and that of Priovolos (1987) for the production of iron ore in Mexico for the period 1960-1984, calculated at 0.84, but close to those that calculated for Canada (2.19) and Spain (1.94). It is worth mentioning

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that Labson et al. (1995) calculated for the 1972-1992 period, price offer elasticities for iron ore significantly lower for China (0.13), Brazil (0.26), Eastern Europe (0.04), Australia (0.30), India (0.10) and North America (0.04); These results differ from those found in this research paper.

On the other hand, steel consumption in Mexico was inelastic with a value of -0.1284, somewhat lower than that calculated by Malanichev and Vorobyev (2011) for world steel demand, which were calculated in the range of -0.2 to -0.3. Priovolos (1987) calculated for the world apparent consumption of iron ore in the period 1960-1984 own price elasticities in the range of -0.04 and -0.64, for China and Spain obtained values similar to the calculated in this work with -0.12 and -0.13, for the United States, Belgium, the United Kingdom and Italy, it obtained values close to -0.16, -0.17, -0.10 and -0.15. On the other hand, Labson et al. (1995) calculated for the period 1972-1992, price elasticities of steel demand for China of -0.28, Brazil -0.33, European Union -0.07, Australia -0.05, Japan -0.04 and India -0.02.

With regard to the effect of price transmission, the unit changes in the steel wholesale price provoke adjustments on the price to the consumer and the producer, at a rate of 0.7872 and 0.9727. On the other hand, a unitary percentage change in the cost of real transportation in Mexico causes an adjustment of the wholesale price at 1.05% and 0.05% if the international price of steel increases in the same magnitude.

In the long term, the estimated elasticities indicate that steel production in Mexico will respond elastically (15,998) and steel consumption in elastically (-0,2002), before changes in their respective real prices (Table 3). This price elasticity of steel consumption in Mexico is close to that calculated by Aravena and Hofman (2006) for Latin America in the period 1980-2004 (-0.26). Labson et al. (1995) calculated for the period 1972-1992, China elasticities of 0.85, Brazil 0.66, Eastern Europe 0.21, Australia 0.43, India 0.72 and North America 0.04.

Table 3. Own price elasticities and transmission of short and long-term prices.

Exogenous variables	Endogenous variables				
Short term	CAM	PACMR	PAMMR	PAPMR	PAM
PACMR	- 0.1284				
PAPMRL			;		2.3863
PAMMR		0.7872		0.9727	
CTAMR			1.0521		
PINTARL			0.0513		
Long term					
PACMR	- 0.2002				
PAPMRL					15.9980

If the Annual Average Rates of Growth (TMAC's) recorded from 2010 to 2015 are maintained, in consumer and producer prices (11.6 and 6%), it will have an impact on a decrease and an increase in the quantity consumed and produced of steel Mexican on the order of 1.5 and 14.3%, respectively; The TMAC registered in the wholesale price was 6% and if this is maintained it will affect the consumer price and the steel producer in 4.7 and 5.8%. The cost of transport and the international price registered rates of 6 and 2.6%, which generates adjustments in the steel wholesale price of the order of 6.3 and 0.3%, respectively; if these levels of change is maintained.

In relation to the other factors that most affect domestic steel consumption (CAM), it was found that in the face of unitary increases in the urbanization process less than directly reacted (0.4843), like the index of the price of housing in Mexico (0.3762) and changes in national income per capita (0.4544). The increases registered,

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during the period 2010-2015, by the TMAC´s of the urbanization process (3.7%), the house price index (2.1%) and the national income per capita (10.2%) directly affect to CAM; that is, they increase it by 1.8, 0.8 and 4.6%, respectively (Table 4).

Crompton (2015), for steel consumption in 26 member countries of the Organization for Economic Cooperation and Development (OECD) found income elasticities in the range of 0.01 (Norway) and 4.05 (Greece); he highlights that for the United Kingdom, Switzerland and the United States he calculated elasticities close to that of this work. In relation to the urbanization process, Crompton (2015), found negative elasticities for Sweden and Japan, the rest were positive; and, close to the one calculated in this paper for Portugal, the United States, Italy, Canada, Spain, Australia and Greece. On the other hand, Labson et al. (1995) calculated elasticities of steel demand with respect to industrial production for China of 0.38, India 0.78, European Union 2.11, Australia 2.33, Japan 2.12 and Brazil 3.65 for the period 1972-1992.

In relation to steel production (PAM), the factors that most affect it are, directly, the price of scrap to the steel producer in Mexico with a cross price elasticity of 0.1579. The price of electric power and the price of oxygen to the steel producer in the country cause a negative reaction with cross-price elasticities of 4.0917 and 1.6371. From 2010 to 2015, the TMAC´s of the price of oxygen to the steel producer, the price of scrap to the steel producer and the price of electric power to the steel producer in Mexico, were -4.3, 9.6 and -1.9 %, which affects PAM in 7, 1.5 and 7.8%.

For the long term, a unit percentage increase in per capita national income and the production of automotive vehicles in Mexico will increase steel consumption (CAM) by 0.71 and 0.21%. As well as, a unit percentage increase in the urbanization process, the house price index and the gross domestic product of the construction sector would increase CAM by 0.75, 0.59 and 0.14%. Aravena and Hofman (2006) calculated for the period 1980-2004 in Latin America an elasticity of steel demand in relation to the industrial activity of 1.31. The production of steel, the unit percentage increases in the price of electric power and the price of oxygen to the steel producer in Mexico will negatively impact the order of 27.43 and 10.98%. The price of scrap to the steel producer in Mexico will directly impact PAM, a unit percentage increase in this factor will increase the production quoted by 1.06%.

Table 4. Short and long term elasticities related to other factors that affect the consumption and production of Mexican steel.

Endogenous variables	Exogenous variables					
Short term	PIBSCR2L	PVAM2L	IPVM	INBPRL	PU	CAML
CAM	0.0904	0.1348	0.3762	0.4544	0.484	0.351
	PCHPAR	PEEPARL	PO2PARL	PAML		
PAM	0.1579	-4.0917	-1.6371	0.8399		
Long term	PIBSCR2L	PVAM2L	IPVM	INBPRL	PU	
CAM	0.1410	0.2101	0.5864	0.7084	0.755	
	PCHPAR	PEEPARL	PO2PARL			
PAM	1.0584	-27.4310	-10.9753			

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Elasticities of the reduced form

On the balance of foreign trade of steel in Mexico (SCA), the positive effect is greater in the face of unit changes in the price of electric power to the steel producer (160.29), followed by the price of oxygen to the steel producer (-64.13), the urbanization process (23.01), the national income per capita (21.59) and the housing price index in Mexico (17.87) and, the negative effect is greater in the face of unitary changes in the steel producer price (- 93.48), the scrap price to the steel producer (-6.18) and the steel consumer price in Mexico (-6.1) (Table 5).

Table 5. Elasticities estimated for SCA.

	Exogenous variables					
	PACMR	PIBSCR2L	PVAM2L	IPVM	INBPRL	PU
SCA	-6.1026	4.2963	6.4027	17.8724	21.5904	23.0117
	CAML	PAPMRL	PCHPAR	PEEPARL	PO2PARL	PAML
SCA	16.6515	-93.4838	-6.1846	160.2919	64.1336	-32.9039
	D	CTAMR	PINTARL			
SCA	1.4148	-5.0544	-0.2464			

If the TMAC´s from 2010 to 2015 are kept in the short term registered in consumer prices and the steel producer in Mexico (11.6 and 1.6%), they will have a decrease in SCA in the order of 70.7 and 149.6%. A unitary percentage increase in the Gross Domestic Product of the construction sector and in the production of motor vehicles in Mexico, positively affects the SCA by 4.3 and 6.4%; as well as one aroused in the price of scrap in Mexico affects the SCA negatively by 6.18%. While a unitary change in the cost of transport and the international price of steel, impacts in an inverse way on the SCA (-5.05 and -0.25%).

IV. CONCLUSION

The consumption of steel in Mexico responds inelastically to changes in the price to the consumer, while the supply of steel responds elastically to changes in the producer price.

With regard to the transmission of prices, the effect of the wholesale price of steel on the producer price is greater; in comparison to what it has on the price to the consumer.

The marginal effect of the international steel price on the wholesale price in Mexico, compared to the more than proportional change that the national transportation cost brings about; it reflects in part the integral problems existing in the local communication channels.

The research hypotheses proposed are not rejected, given that the results show that steel consumption in Mexico is determined inversely by the price to the consumer and directly by income and the urbanization process. The supply of steel presented a direct determination by the price to the producer and inversely by the price of the inputs, such as: scrap, electric power and oxygen.

Finally, prices to the consumer and the steel producer in Mexico are directly affected by the wholesale price and the effect of the international price on the latter is positive.

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