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ECONOMIC ANALYSIS OF STEEL CONSUMPTION IN MEXICO

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ABSTRACT

In 2016, the apparent world consumption of steel was more than 1,630 million tons. World exports of steel were concentrated by China and Japan with 22.8%, Mexico imported 21% of those made by North America; what impacted on the internal dynamics of its steel consumption. To determine the effect of the change in the main factors that explain the consumption of Mexican steel; 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 2016; integrated by 3 regression equations. The results indicate that in the short term the steel consumption in Mexico responds inelastically (-0.2354%) before changes of 1% in the own price. 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 0.5518, 0.4720 and 0.3596. The effect of the international price of steel and the cost of transportation in Mexico, affect the wholesale price at a level of 0.0513 and 1.0521%, for each unit percentage change in the first ones.

Keywords: Consumption, steel, simultaneous equations, elasticities.

1. INTRODUCTION

In the decade of the 90's world trade in iron ore and steel was undergoing a major restructuring. Developing economies in regions such as China, India and South Korea emerged as growth centers for the sector. Alternatively, the industrialized economies of the European Union, Japan and North America were gradually losing their dominant role (Labson, 1997).

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In 2016, steel exports were 473.7 million tons (Mt); Asia exported a total of 211.9 Mt, which represented 44.7% of exports worldwide. The three most representative exporting countries in the Asian continent were: China with 108.1 Mt (51%), Japan 40.8 Mt (19.1%), and South Korea with 30.6 Mt (14.4%). The European Union exported a total of 140.6 Mt, which represented 29.7% of exports worldwide. The three countries with the largest share of exports from the European Union were: Germany (25.1 Mt), Italy (17.9 Mt), Belgium (16.7 Mt), France (13.7 Mt) and The Netherlands (10.2 Mt). In the Americas, steel exports, during 2016, behaved as follows: In North America, exports amounted to 29.4 Mt, representing 4.1% of world exports, with the three most representative exporters in this region: United States with a participation of 9.2 Mt, Canada with 5.8 Mt, and Mexico with 4.1 Mt. With respect to South America, the export was of 14.3 Mt representing 3% of world exports; Brazil was the largest exporter with 13.4 Mt. In Africa, the export of steel from South Africa stood at 2.2 Mt. Other important exporters were Russia (31.2 Mt), Ukraine (18.2 Mt), Turkey (15.3 Mt), Iran (5.7 Mt) and United Arab Emirates (3.3 Mt). (WSA, 2017).

With regard to steel imports, in 2016, a total of 461.3 Mt. Asia imported a total of 149.3 Mt, which represented 32.4% of the world total, the three most representative importing countries were: Korea South (23.3 Mt), Vietnam (19.5 Mt), Thailand (17.6 Mt), China (13.6 Mt), Indonesia (12.6 Mt) and India (9.9 Mt). The European Union imported a total of 148.2 Mt, which represented 32.1% of world imports; The three countries with the highest participation were: Germany (25.5 Mt), Italy (19.6 Mt), France (14.6 Mt) and Belgium (13 Mt). Africa imported 29.7 Mt, which represented 6.4% of the total imports in the world; The imports from Egypt (9.2 Mt), Algeria (5.5 Mt), and Morocco (2.2 Mt) stand.

In the American continent, imports of steel behaved as follows: North America imported 53.2 Mt, which represented 11.5% of the world totals, being the three most representative importers: the United States (30.9 Mt), Mexico (9.7 Mt) and Canada (7.7 Mt). In South America, the import of steel was 11.8 Mt, representing 2.6% of the world import; In this region, imports from Colombia (2.7 Mt), Peru (2.2 Mt), Chile (1.8 Mt), Brazil (1.7 Mt), Ecuador (0.9 Mt) and Argentina (0.8 Mt) stood out (WSA, 2017).

During 2016, Mexico ranked 13th as an international steel producer, representing 1.2% of the world production of 1,628 Mt. As regards Latin America, steel production was 59.7 Mt, and Mexico ranked second. place after Brazil (31.3 Mt), which in sum represented 84% of the total production in the region (WSA, 2017). In December 2016, with seasonally adjusted figures, the 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

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heterogeneous behavior among the different minerals that make up the mining-metallurgical production, the gypsum, carbon, lead, sulfur, zinc, silver, gold and fluorite, mainly, decreased. In contrast, iron, copper and dolomite pellets rose only marginally (INEGI, 2017a).

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 national 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).

Notwithstanding the foregoing, in 2016 Mexico imported 18.2% of those made by North America (WSA, 2017); derived from the consumption of steel by the automotive industry, the oil industry and the construction industry. This was to the detriment of the strategic action plan for the steel sector in Mexico, which in 2008 the National Chamber of the Iron and Steel Industry (CANACERO) and the Ministry of Economy (SE) presented, with the purpose of duplicating the steel sector GDP for 2020 from 6 thousand MDD to 12 thousand MDD, this represented 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 involved 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).

For the aforementioned, the objective in this work was the identification of the factors that influence the demand of the national steel, which in turn have an impact on the consumer price and the wholesale of Mexican steel, 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 meet domestic demand (in 2016 the figure for imported steel represented 51.6% of national production) and, 2) development planning in the national steel sector without having indicators and estimates that contribute with 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; and, 2) The steel consumer price in Mexico is directly impacted by the wholesale price and the effect of the international (import) price on the latter is positive.

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2. METHODOLOGY

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

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

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

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

(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 consumption of steel in Mexico was determined by calculating the elasticities, via the results obtained from a simultaneous equations model composed of a consumption equation and two transmission equations. prices. The econometric model of steel consumption in the country in its structural

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form was formulated by adding to the functional relationships, structural coefficients or α's, which represent the estimators of the parameters of each variable and the ε's or the stochastic term:

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

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

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

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 ($); $PIBSARL_{t-1}$ = Gross domestic product of the automotive sector in real Mexico with a one-year 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 (%); $INBPRL_{t-1}$ = Gross national income per capita in Mexico with one year of lag ($/inhabitant); PU_t = urbanization process in Mexico [(urban population/rural population)*100] (%); $CAML_{t-1}$ = Amount of steel consumed in Mexico with one year of lag (t); $PAMMR_t$ = Real price of wholesale steel in Mexico ($/t); D_t = Classification variable with zero from 1980 to 1986 representing the closed economy period, and one from 1987 to 2015 represented the open economy; $CTAMR_t$ = cost of transporting steel in Mexico ($/t); $PINTARL_{t-1}$ = International price of steel with one year of delay-variable proxy the price of steel in China ($/t).

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 and e) The errors do not present serial correlation, that is, $E(\varepsilon_t\ \varepsilon_{t-1}) = 0$.

For the aforementioned variables, time series with annual information for the 1980-2016 period were formed 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.

Equation 5 models the consumption of steel in the country, equations 6 models the effect of transmission that the real price of wholesale steel in Mexico has on the real price of steel to the

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consumer and equation 7 models the effect that the cost of transport and the price to the steel producer in China have on the wholesale price in Mexico, since it is the main producer country.

The model was based on empirical evidence from works such as: Aravena and Hofman, 2006; Coeymans, 2006; Crompton, 2015; Giuliodori and Rodriguez, 2015; Labson et al., 1995; Malanichev and Vorobyev, 2011; Priovolos, 1987; Vergara, 2006; Wårell, 2014; Xuan and Yue, 2016; Yin and Chen, 2013.

2.2 Data of the model variables

The amount of steel consumed in Mexico was obtained from WSA (several years); The steel consumer price in Mexico, the wholesale steel price in Mexico, the transport cost of steel in Mexico, the price of steel in China was used as a proxy variable of the international price of steel were obtained from CANACERO (several years); The gross domestic product of the construction sector in Mexico, the gross domestic product of the automotive sector in Mexico, the gross national income in Mexico and the production of motor vehicles in Mexico were obtained from INEGI-BIE (2017a); The information for the calculation of the urbanization process in Mexico was obtained from INEGI (2017b).

The monetary series were deflated with: the National Consumer 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), as well as the housing price index in Mexico.

2.3 Estimation method

The coefficients of the model were estimated with the two-stage least squares method (MC2E) (Wooldridge, 2009; Gujarati and Porter, 2009) using the statistical package SAS (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 coefficient through the Student's t and the normality of the variables with the Shapiro-Wilk test (SW). The microeconomic theory of demand (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 that affects steel consumption at the national level. The

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short-term price elasticities (*Ep, cp*) at any point on the curve, it is given by (Gujarati and Porter, 2009):

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

where: $(\partial Q_t / \partial P_t)$, is the slope of the demand curve (b_1) and P_t and Q_t, they are the price received by the consumer in year t and the amount consumed in year t.

To calculate the cross-elasticities with respect to the other determinants of consumption, the respective coefficients, price and quantity were used. To obtain the long-term elasticities, the respective coefficients of the long-term model were used, which were obtained by dividing the short-term coefficients by the coefficient of the adjustment rate (γ) and eliminating the lagged amount Q_{t-1}:

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

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

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

The long-term cross-elasticities for the other factors were calculated using the respective coefficients of the long-term model.

3. RESULTS AND DISCUSSION

The three regression equations of the model in its structural form presented a high goodness of fit with coefficients of adjusted determination (R^2 Ajust) of 0.92 to 0.99, the value of the test of *F* of each equation was significant at a level of 0.01, the Statistical DW indicates the existence of a low level of autocorrelation between the time series (1.94 - 2.21) and the value of SW per variable ranged between 0.93 and 0.98; 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 demand.

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Table 1: Results of the model.

CAM=4853127-74.0910*PACMR*+0.0000002245*PIBSCR2L*+0.000001894*PIBSARL*

t	(1.69**)	(-1.83*)	(1.62**)	(1.38*)
Error sd.	2866843	40.48688	0.0000001372	0.00000494
SW		0.94	0.95	0.92

+25.1072*PVAM2L* +106926.6*IPVM*+81.87*INBPRL*+21001.34*PU*+0.373095*CAML*

t	(0.98***)	(2.27***)	(2.72**)	(1.54*)	(2.28***)
Error sd.	25.62109	47135.08	30.08322	13636.15	0.163499
SW	0.98	0.93	0.97	0.95	0.96

R^2=0.94; R^2Ajust=0.92; Pr > F=0.0001; DW=2.21; BP[1]=1.89

PACMR=18230.14 + 0.273279*PAMMR* -7246.70*D*

t	(3.75***)	(26.61***)	(-1.47*)
Error sd.	4866.433	0.010269	4922.264
SW		0.96	0.94

R^2=0.98; R^2Ajust=0.98; Pr > F=0.0001; DW=1.94; BP=1.77

PAMMR = 19977.74+ 6.218274*CTAMR* + 0.630545*PINTARL*-24303.8*D*

t	(2.26**)	(70.36***)	(2.22**)	(-3.35***)
Error sd.	8839.996	0.088381	0.284432	7257.934
SW		0.95	0.97	0.93

R^2=0.99; R^2Ajust=0.99; Pr > F=0.0001; DW=1.97; BP=1.83

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

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

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3.1 Short and long term elasticities

In the short term, the own price elasticities estimated in the structural form of the model indicate that steel consumption in Mexico is inelastic with value of -0.2354, similar to that calculated by Malanichev and Vorobyev (2011) for the global steel demand that 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 cause adjustments on the consumer price, at a rate of 0.7877. 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 the steel consumption will respond inelastically (-0.3755), before changes in its real price (Table 2). This price elasticity of steel consumption in Mexico is higher than the one 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, elasticities for China of 0.85, Brazil 0.66, Eastern Europe 0.21, Australia 0.43, India 0.72 and North America 0.04.

Table 2: Own price elasticity and transmission of short and long-term prices.

Exogenous variables	Endogenous variables		
Short term	CAM	PACMR	PAMMR
PACMR	-0.2354		
PAMMR		0.7872	
CTAMR			1.0521
PINTARL			0.0513
Long term			
PACMR	-0.3755		

If the Annual Average Growth Rate (TMAC) is maintained from 2010 to 2016, in the consumer price (11.8%), it will result in a decrease in the amount consumed of Mexican steel of the order

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of 2.8%; the TMAC recorded in the wholesale price was 6.4% and if this is maintained it will affect the consumer price by 5.04%. The cost of transport and the international price registered rates of 6.7 and 3%, which generates adjustments in the steel wholesale price of the order of 7.05 and 0.15%, respectively.

In relation to the other factors that most affect national steel consumption (CAM), it was found that in the face of unitary increases in the urbanization process, less that it reacts directly (0.5518), as does the index of the price of housing in Mexico (0.3596) and changes in national income per capita (0.4544). The increases recorded, during the period 2010-2016, by the TMAC´s of the urbanization process (3.8%), the house price index (2.4%) and the national income per capita (10.7%) directly affect to CAM; that is, they increase it by 2.1, 0.86 and 5.05%, respectively (Table 3).

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.

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 0.75 and 0.24%. As well as, a unit percentage increase in the urbanization process, the house price index, the gross domestic product of the construction sector and the gross domestic product of the automotive sector would increase CAM by 0.88, 0.57, 0.10 and 0.18%. 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.

Table 3: Short and long term elasticities related to other factors that affect Mexican steel consumption.

Variables endogenous	Exogenous variables						
Short term	PIBSCR2L	PIBSARL	PVAM2L	IPVM	INBPRL	PU	CAML
CAM	0.0627	0.1148	0.1519	0.3596	0.4720	0.5518	0.3646
Long term	PIBSCR2L	PIBSARL	PVAM2L	IPVM	INBPRL	PU	
CAM	0.1001	0.1831	0.2423	0.5737	0.7528	0.8802	

4. CONCLUSIONS

The consumption of steel in Mexico responds inelastically to changes in the price to the consumer.

With regard to the transmission of prices, the effect of the wholesale price of steel on the price to the consumer is significant.

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; In part, it reflects the integral problems existing in the internal 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.

Finally, the steel consumer price in Mexico is directly affected by the wholesale price and the effect of the international price on the latter if it is positive.

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