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The Impact Analysis of the Variation in the Price of Oil and the Exchange Rate on the Optimal Quantity of Orders in the Zinc Importing Companies in Colombia

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ABSTRACT

This paper analyses the impact of oil price and exchange rate variations on the economic order quantity (EOQ) of the zinc importing industry in Colombia. As a methodology, a vector autoregressive model (VAR) is applied, which allows quantifying how the variation of one variable impacts another in a dynamic system of equations. The results show a negative impact on EOQ by exchange rate revaluation due to increased import costs. On the other hand, oil price increments generate growth in the EOQ because the peso appreciates, purchasing imported raw materials inexpensive.

Keywords: Economic Order Quantity, EOQ, Oil, Inventory Policy, Exchange Rate, VAR
JEL Classifications: E22, E44, G31

1. INTRODUCTION

Given the global competition that requires increasing business competitiveness, companies must have an adequate inventory control system. A good inventory policy with rigorous controls brings with it advantages such as reduced costs and production times, increased customer satisfaction, improvements in production efficiency, benefits of economies of scale, minimization of expenses in inventory investment, among others, (Ballod, 2014).

Nonetheless, in a globalized world where markets are interdependent, companies can see their operations affected by fluctuations in the international prices of different raw materials. According to the above, the supply chain of a given industry can be impacted by the increase in fuel prices (Andriolo et al., 2014), which is linked to the prices of energy raw materials such as petroleum. In addition, if an organization needs to import raw materials for its operation, the volatility of the exchange rate will affect the transaction costs (Bergstrand, 1985 y Reinhart, 1995). Due to this, it can be identified that the supply chain of the different companies related to imports or exports are susceptible to the volatility of economic and financial variables such as exchange rates and oil prices (Hammoudeh and Yuan, 2008).

In oil-exporting countries like Colombia, the exchange rate is strongly linked to the price of oil (De Truchis y Keddad, 2016, Golub, 1983), since, if its prices increase, there is an introduction of international currencies to the economy, which generates a devaluation of currencies such as the dollar leads to its great use for international transactions (Sinnott et al., 2010). Therefore, the increase in oil prices affects the volatility of the exchange rate, but in turn, it can increase the cost of fuel, making it relevant to identify how it impacts the supply chain and inventory management. The latter, with the purpose that decision makers in the business sector can optimize their operation.

Considering that inventories represent an asset due to the fact that there is a significant investment of money, it would be convenient to take into consideration the models of economic order quantity (EOQ), elements involved in risk and return. Furthermore, it is necessary to take into account factors, such as the price of oil and the exchange rate that allows determining the effects that these variables cause on the EOQ. This can be achieved by using vector autoregressive models (VAR). Thus, establishing the relationship that exists between the exchange rate, oil prices and the EOQ to determine what measures should be addressed regarding decision making in this field (Rodríguez, 2002).

Hereby, this in investigation seeks to answer the questions:

What is the impact of the variation in the price of oil and the exchange rate on the EOQ of a zinc importing industry in Colombia? To solve this question, we intend to use econometric models such as autoregressive vectors (VAR) that, through a system of equations, allow us to identify how the fluctuations of one variable impact on another. Finally, this article is divided into five sections: introduction, theoretical framework, methodology, results, and conclusions

2. LITERATURE REVIEW

2.1. Supply Chain

According to Zuluaga et al. (2014), a supply chain is a network of facilities and distribution that involves transportation in the movement of raw materials, finished and semi-finished products from one entity to another. This includes all the operations carried out by a company, from the acquisition of resources that it needs to function, to the production and delivery of the goods it produces (Oca et al., 2018). In the supply chain, quantitative criteria, such as money must be taken into account (Klibi et al., 2010) and qualitative criteria, such as government policies, human, financial, and information resources, among others, that generate risk in decision making for each of the links in the chain (Jiménez et al., 2021).

Consequently, within the chain the distribution network is influenced by transport costs since they are increased by distance. The greater the distance travelled, the greater the cost, and this cost affects the chain, due to the increase in fuel prices. Authors, such as Andriolo et al. (2014) determine that transportation costs are increasing, becoming an increasingly important factor in lot size and inventory decisions, since fuel prices are directly related to prices of raw materials such as petroleum, which causes an increase in oil prices to generate an increase in fuel prices (Gurtu et al., 2015), which in turn directly impacts the transportation in the supply chain, affecting EOQ and lot size.

2.2. Petroleum-Dollar and Raw Materials

The relationship between the price of the dollar and the prices of raw materials traded in this currency is based on the law of a single price for tradable goods. Bearing in mind this law, it can be argued that a decrease in the price of the dollar should be amortized through an increase in the prices of raw materials in dollars, in order to guarantee the maintenance of the level of the amount measured in dollars. Likewise, given that in most international markets raw materials are traded in dollars, a decrease in the price of this currency increases the purchasing power and the purchase of raw materials by external consumers (Gilbert, 2010).

On the other hand, the price of oil in countries that are dedicated to its export affects the exchange rate and could present a phenomenon that brings an adverse effect on the industry of a country known as the Dutch disease. As a result of this, it generates deindustrialization and productive dependence on tradable sectors such as mining, exposing the local currency to revaluation, (Corden, 1984). Poncela et al. (2017) in a study carried out for Colombia, find indications of the existence of cointegration between the exchange rate and the price of a barrel of crude oil. This study identifies that a rise in oil prices in Colombia generates an appreciation of the currency.

Similarly, in countries that export oil, such as Colombia, oil prices have large effects on the exchange rate, which can have repercussions on business operations. Likewise, according to data from the National Department of Statistics of Colombia (DANE- for its acronym in Spanish) it can be verified that oil and its derived products have an important weight in the total of all exports carried out by Colombia. Since the barrel of oil is traded based on the prices stipulated in the international market, a large percentage of the country's exports are subject to a price which has influences that are beyond its control. This leads to the consequence where a large amount of the dollars that enter the country due to exports are also subject to the price of a barrel of oil, therefore, at a lower price, fewer dollars enter and the representative market rate (TRM-for its acronym in Spanish) increases (Candelo, 2018).

2.3. Inventories, Petroleum, and Exchange Rate

Ramírez and Manotas-Duque (2014), identify that within organizations it is important to carry out inventory management as an investment. Since decisions are made that are continuously affected by a wide range of possibilities, forcing companies to consider the possible adverse effects that it brings to the inventory management policy. For Rodríguez (2002), when considering inventories as an investment project, it should be considered that we are facing uncertain variables, such as the exchange rate that affects the price of imported raw materials, hence, it is necessary to examine the different possible actions to take.

Perilla (2011) explains how the variation in crude oil prices alters the cost of production, this due to the use of fuels and other derivatives. Besides this, it is also affecting investment decision-making, such as inventories. Since there is an appreciation of the local currency, importing raw materials can be carried out locally at lower cost. On the other hand, Frenkel and Ros (2006) have carried out studies on how the variation in oil prices has effects on the exchange rate. Lanteri (2012), proposes a VAR model considering variables such as stock ratios, monetary policies, exchange rates, among other variables, to determine the role that inventories play in the price of agricultural raw materials, leading to the results that these prices are affected by the depreciation of the dollar.

In accordance with Lenard and Roy, cited by Santos and Rodrigues in the control of inventory levels studied by Harris in 1913, the aim is to include the formulation of an economic order quantity (EOQ), which is very important to enhance the level of inventory in a company, so inventory represents a large part of logistics costs. These take into account the opportunity cost of maintaining inventories. Overall, Ray and Chaudhuri (1997), formulate a model derived from the EOQ, which considers items such as macroeconomic factors such as the value of money over time and inflation rates.

Teksan and Geunes (2016) propose an EOQ model considering the influence of the price of supplies, products in the economy and the profitability of production. Furthermore, in the process they are able to identify remarkable relationships between model parameters and the characteristics of optimal pricing and production planning decisions, as well as optimal profit per time unit and production profit margins. Cepeda and Jiménez (2016) state a dynamic inventory model taking into account economic variables such as market needs, price variations and the influence this has on inventories.

León-Orozco (2020), make use of the EOQ model, and based on autoregressive vectors (VAR- from its acronym in Spanish) to carry out the purchase of raw materials in order to establish the importance between inventories and how these have an impact on the cash flow. Bulinskaya (2003), insists on the exploration of new points of view on how to address the management of inventory problems, delving into a broader scope of financial risk management. Mohr (2017) takes into consideration the making of optimal supply decisions considering the variation in prices, treating inventory problems hand in hand with making financial decisions. Hammoudeh and Yuan, (2008) express that the prices of materials have a unified behaviour because they are usually affected by macroeconomic factors, such as exchange rates, inflation, and the production of the industries.

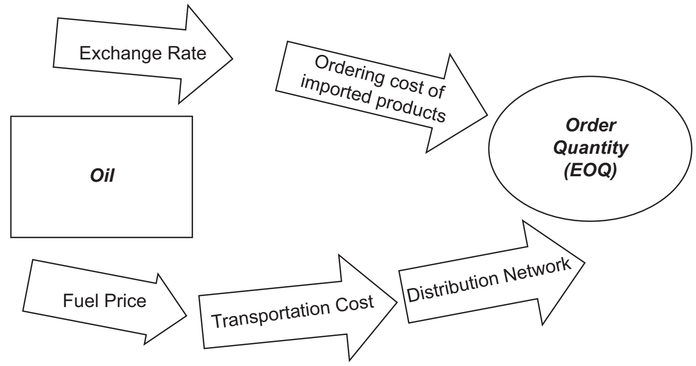
For this reason, oil exporting countries like Colombia see their exchange rate affected, by the fluctuation of the prices of that raw material (Candelo--Viafara y Oviedo-Gómez, 2021), in this sense, when the exchange rates fluctuate, the prices of imported raw materials for different companies vary, which means that a variation in the exchange rate can increase order costs, affect the inventory level and, therefore the EOQ.

Figure 1, shows the relationship between the variables mentioned in this theoretical framework. It can be seen that oil prices can affect the EOQ in two ways; the first one occurs when oil prices fluctuate, affecting the exchange rate and therefore the costs of ordering imported products, which ends up impacting the quantity of the final order. The second one occurs when oil prices fluctuate, fuel prices are affected, impacting transportation costs and the distribution network.

3. MATERIALS AND METHODS

This research aim is to identify the impact of the increase in oil prices and the exchange rate on the economic order quantity

Figure 1: Relationship between oil prices and the exchange rate with the EOQ



(EOQ). EOQ proposed by Wilson (1934) is initially calculated, and then a Vector Autoregressive model (VAR) proposed by Sims (1980) is used, given that it is one of the most widely used econometric models that allows identifying how the fluctuations of financial or macroeconomic variables impact a specific variable. This methodology has been used by different authors to analyze its impact on different elements of the supply and inventory chain, such as Alshami and Muley (2020), Almaraj and Trafalis (2020), Lanteri (2012), León-Orozco (2020). Additionally, the autoregressive vector methodology has been used by Candelo-Viafara and Oviedo-Gómez (2020) to measure the impact of the prices of some commodities on the Colombian industrial operation.

According to the above, the EOQ is given by the following equation [1]

$$Q = \sqrt{\frac{2AD}{vr}} \tag{1}$$

Where □ is the quantities to order, □ is the cost of ordering, □ is the monthly demand for the item, □ is the unit value of the item and □ is the percentage cost of inventory maintenance. After calculating the EOQ, an Autoregressive Vector model (VAR) proposed by Sims (1980) will be estimated, which allows measuring the impact of one variable on another in a dynamic system of equations, eliminating endogeneity problems. The structural VAR model can be expressed for two variables as follows:

$$y_t = b_{11} + b_{12}x_t + b_{13}y_{t-1} + b_{14}x_{t-1} + e_{y_t} \tag{2}$$

$$x_t = b_{21} + b_{22}y_t + b_{13}y_{t-1} + b_{14}x_{t-1} + e_{x_t} \tag{3}$$

Where x_t and y_t are the stationary endogenous variables, e_{yt} and e_{xt} are white noise errors with zero mean and constant variance. It can be written in matrix form as follows:

$$Bz_t = {}_o + {}_1 z_{t-1} + e_{z_t} \tag{4}$$

Where □ is the matrix that contains the estimation parameters of the variables in the same time period, z_t is the vector of endogenous variables, δ_0 contains the constants of the model, δ_1 is the matrix of lag estimators, z_{t-1} is the vector of lagged variables, e_{zt} are the errors of the model. The vectors and matrices of the model can be seen below:

$$B = \begin{bmatrix} 1 & -b_{11} \\ -b_{21} & 1 \end{bmatrix}; z_t = \begin{bmatrix} y_t \\ x_t \end{bmatrix};_o = \begin{bmatrix} b_{11} \\ b_{21} \end{bmatrix} = \begin{bmatrix} b_{13} & b_{14} \\ b_{23} & b_{24} \end{bmatrix}$$

$$z_{t-1} = \begin{bmatrix} y_{t-1} \\ x_{t-1} \end{bmatrix}; e_{zt} = \begin{bmatrix} e_{y_t} \\ e_{x_t} \end{bmatrix}$$

Finally, the following equation shows the VAR model in a simplified version, which can be represented as follows:

$$Z_t =_o +_1 z_{t-1} + e_{z_t} \quad (5)$$

3.1. Data

To determine the relationship between the EOQ, oil prices and the exchange rate, data provided by DANE on the quantities of raw materials imported at the national level and in this particular case, from the zinc importing industry in Colombia due to data availability, similarly, a history of the TRM values reported by the Banco de la republica from Colombia, and the Brent oil prices reported in FRED data were used.

In particular, to calculate how many tons of a certain material was imported at the national level, the results presented by DANE were used. The amounts are shown in billions of dollars in this information, making it necessary to use the historical prices that are used in the international markets, in order to be able to calculate how many tons of the chemical substance were imported. Table 1 describes the variables used, units and their source.

In like manner, the EOQ was calculated for the entire zinc importing sector in Colombia as a case study, making an estimate of 61 months in the period from May 2016 to May 2021. The unit order cost necessary to estimate the EOQ is calculated by multiplying the value of tons of zinc in the market by 0.5%. The demand for Zinc is obtained from the number of tons in the national market reported by DANE, likewise, the price of each ton was obtained from FRED data. Finally, the cost of inventory maintenance is established at 2% according to Vidal, (2010).

In accordance with the above, the vector of variables that will allow us to identify the impact of the exchange rate and oil prices on the EOQ is presented below,

$$y_t = [Brent, RMR, pzinc, EOQ\ ]'$$

Which is organized from the most endogenous variable to the most exogenous.

Where Brent is the international price of a barrel of oil, *RMR* is the representative market rate (peso-dollar) in Colombia, pzinc is the price per ton of Zinc and finally the *EOQ* which is the economic order quantity. It should be noted that the price per ton of Zinc is introduced in the model, due to the negative relationship of this variable with the quantities, since according to the economic and inventory control theory proposed by authors such as Mills (1959), Petruzzi and Dada (1999) and Chen et al. (2006) the higher the prices, the lower the demand for a product.

Figure 2, shows the behaviour of the price of Zinc and the price of Brent oil, where it is noticed that they have a similar behaviour as of the year 2019. Further, it is concluded that there is an inverse relationship between the price of a barrel of Brent oil and the RMR because when the price of a barrel of oil decreases, the price of the dollar increases and vice versa.

Figure 1 depicts that until the end of 2018, the EOQ shows a highly fluctuating behaviour with respect to the variables of the price of a barrel of oil and the exchange rate, highlighting that when the RMR decreases the EOQ increases, this it is due to the fact that there is a negative correlation between these two variables. On the contrary, when crude oil prices increase, the EOQ rises due to the positive correlation between these variables. Finally, as of 2019, it is seen how the EOQ begins to behave similarly to the price of crude oil and inverse to the RMR. Regarding the above, Table 2 shows the descriptive statistics of the variables, in addition to highlighting that all prices are in US dollars.

Table 3 shows the correlation of the variables, considering that if one variable has a positive value with respect to another, it means that they have a directly proportional behaviour, but if the result is negative, it means that the variables have an inverse proportional behaviour. To this extent, it can be deduced that the EOQ only presents a positive correlation concerning to oil prices and presents a negative correlation with the variables of the TRM and the price of a ton of Zinc. The correlations that appear between the EOQ and the TRM are a negative value of –0.323660 toward to the correlation with oil prices, which shows a positive value of 0.126617. On the other hand, the prices of a ton of Zinc present a negative correlation, which is very low because its value is very close to zero –0.05056. It should also be noted that there

Table 1: Description of variables used

Variable	Description	Unit	Source	Name
Zinc imports in Colombia	Colombian imports of Zinc	Millions of US dollars	DANE	Impor Zinc
Price per ton of Zinc	International average monthly price of tons of Zinc	dollars per-ton	Fred Data	Pzinc
Representative market rate RMR	Monthly average Colombian pesos per dollar	Colombian pesos	Bank of the Republic of Colombia	RMR
Brent oil prices	Dollars per barrel	American dollars	Fred Data	Brent

Own production

Figure 2: History of the EOQ, P zinc, TRM and Brent between May 2016 and May 2021

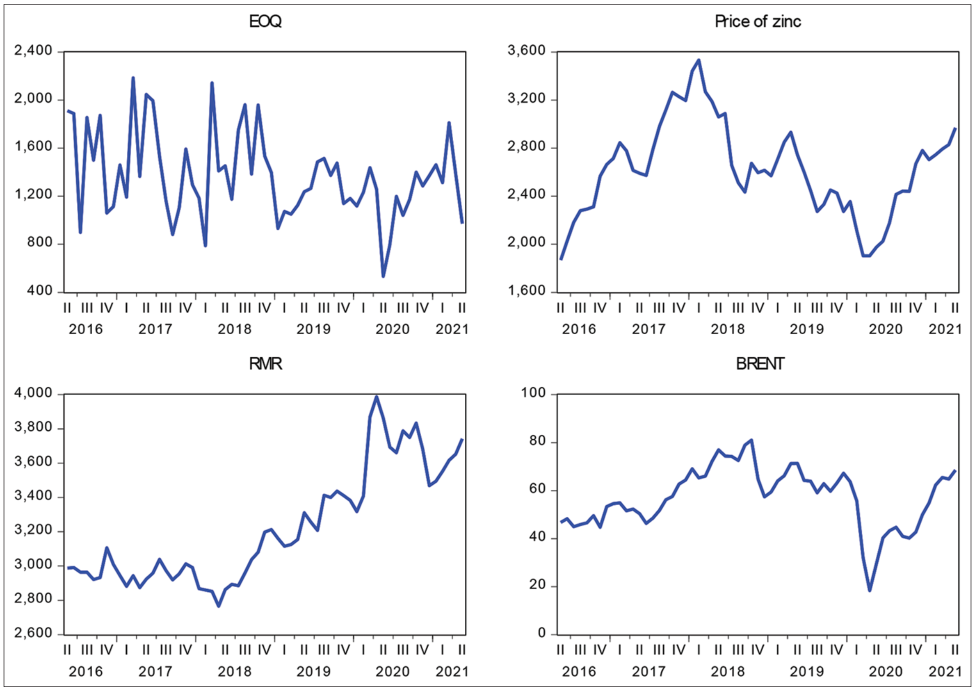


Table 2: Descriptive statistics of the variables

	EOQ	PZinc	Brent	TRM
Mean	1371,682	2619,639	56.92971	3221,686
Medium	1364,856	2614,917	57.50773	3115.150
Maximum	2184,076	3532,900	81.03217	3986,560
Minimum	533.4549	1869,025	18.37850	2765,960
SD	356.1688	387.8775	12.61044	331.1762
Skewness	0.383881	0.153196	-0.487858	0.674193
Kurtosis	2.828554	2.652345	3.226517	2.183997
Observations	61	61	61	61

Own production

Table 3: Correlation of the variables

Variables	EOQ	PZinc	RMR	Brent
EOQ	1			
PZinc	–0.050566	1		
TRM	–0.323660	–0.476780	1	
Brent	0.126617	0.575303	–0.455710	1

Own production

is a negative correlation of –0.0.455710 between the TRM and Brent oil.

4. RESULTS AND DISCUSSION

Figure 3, shows the generalized impulse response functions of the[1] VAR model at two standard deviations; this shows that an increase in the price of tons significantly decreases the EOQ in the first two periods. Also, an increase in the exchange rate has a negative and significant impact on the EOQ in month 3–4 after the impulse and an increase in oil prices positively impacts the EOQ in the 3rd month.

1 To estimate the model, the variables must be stationary so that the mean and variance are constant according to Sims (1980) and since the variables do not meet this requirement, logarithm is applied to them to bring them to similar scales and they are differentiated. The model fulfills stability conditions at four lags

Table 4, shows the variance decomposition that allows us to observe the percentage that the variation in the price of a ton of zinc, the exchange rate and oil prices affect the volatility of the EOQ. The table shows that the price of zinc can affect the variation of the EOQ by an average of 7.20%, the exchange rate can affect the variation of the EOQ by 5.90% and oil prices can affect it by 3.43% variation of the EOQ. All this data is collected in a period of 7 months.

4.1. Stability Tests

To demonstrate that the model is stable, and the results are reliable, four tests must be met; the estimators must have a convergence where the sum of the estimators must be less than one, no autocorrelation, normality, and no heteroscedasticity of the residuals. As mentioned in the previous footnote, these 4 conditions are met when four lags are applied to the model. On paper, Figure 4 shows the test of the root of the characteristic polynomial, where it is identified that the sum of the roots is less than one, since the radius of the circle shown is one unit.

Table 5 shows the test of no autocorrelation for each lag, where the null hypothesis is no autocorrelation and it is seen that the assumption is met, since the probability of each lag of accepting the null hypothesis is greater than 0.05.

Table 6 shows the normality test, where the null hypothesis establishes that the multivariate residuals are normal and, likewise, it is identified that the model meets this test since the probability of each lag accepting the null hypothesis is >0.05.

The last test to look at the stability of the model is non-heteroscedasticity, where the null hypothesis test is non-heteroscedasticity, in Table 7. It can be identified that the model meets this property since the probability of accepting the null hypothesis is >0.05.

Figure 3: EOQ response to Zinc prices, oil prices and exchange rate

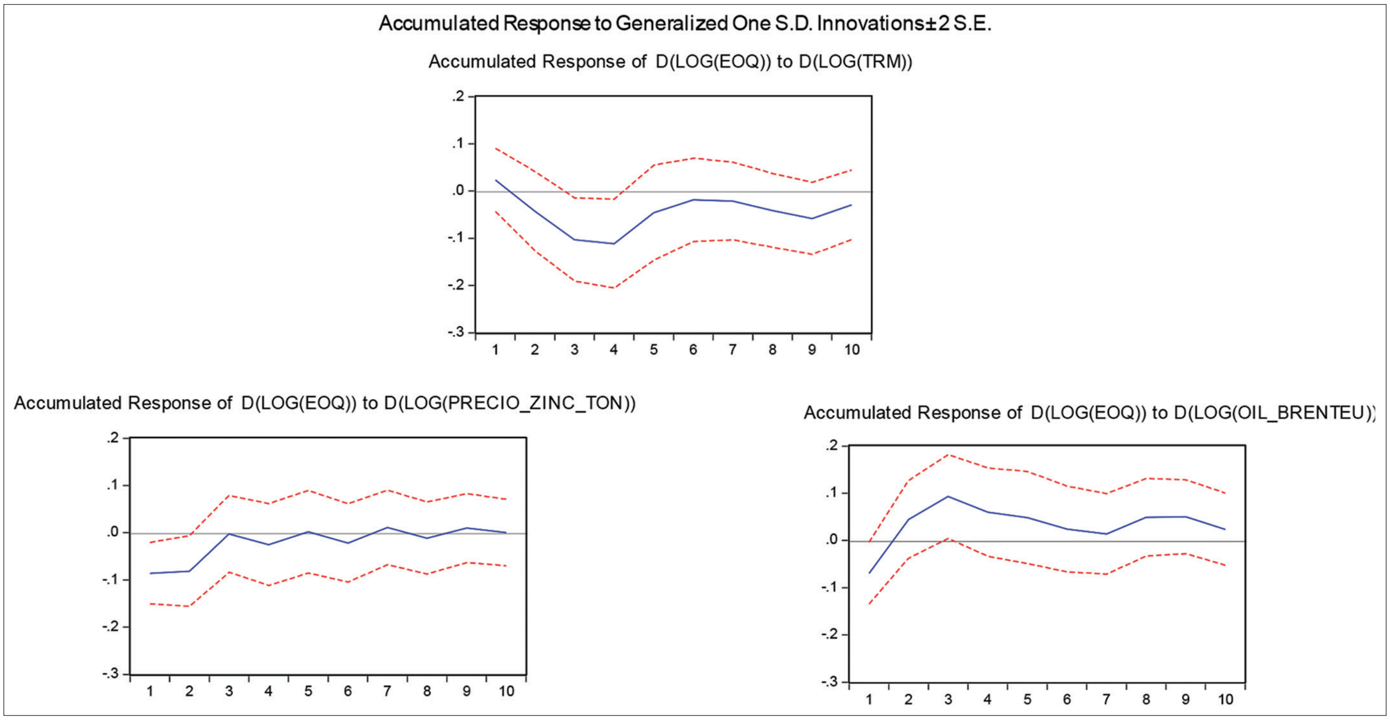
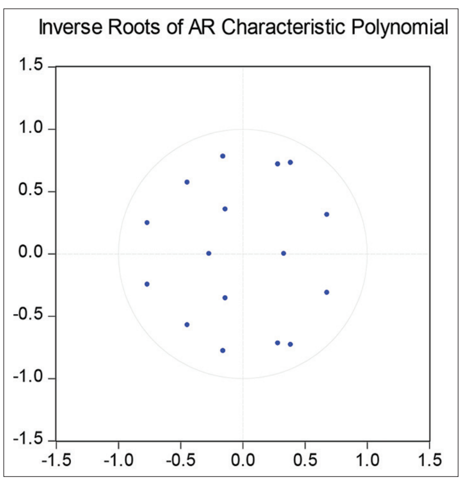


Figure 4: Roots of the characteristic polynomial



Previous estimates have shown that an increase in the exchange rate decreases the EOQ and that, conversely, an increase in oil prices positively affects the EOQ. These results occur given that Colombia is an oil exporting country since there is an inverse relationship between the exchange rate and oil prices (Candelo, 2018), which in turn can affect the supply chain in different ways. In this case, when oil prices increase, there is an increase in dollars circulating in the economy, therefore, the dollar devalues and makes buying imported products cheaper, increasing the EOQ. On the other hand, a rising dollar makes it more expensive to buy raw materials abroad, which lowers the EOQ and purchasing power.

These findings are highly relevant, but the economic characteristics of the country must be taken into consideration, since in countries that do not export raw energy materials, the effect may be

Table 4: Variance decomposition

Variable	Percentage variation of EOQ
Price of Zinc	7.20%
RMR	5.90%
Brent	3.34

Own production

Table 5: Non-autocorrelation test

Null hypothesis: There is no serial autocorrelation	
Lag	Probability
1	0.1176
2	0.1554
3	0.2184
4	0.1108
5	0.3532

Own production

Table 6: Non-autocorrelation test

Null hypothesis: Multivariate residuals are normal	
Lag	Probability
1	0.6338
2	0.7751
3	0.1153
4	0.5139
All residuals together	0.6338

Own production

different, given that authors such as mention that an increase in oil prices increases the value of fuels, which in turn makes the supply chain more expensive, reducing inventories. In this case, for Colombia and the zinc importing sector, the increase in oil prices is compensated by the decrease in the dollar. In addition to the fact that the impact of expensive fuel is much less at high exchange rates.

Table 7: Heteroscedasticity test

Hypothesis: Non-heteroscedasticity	
Chi-square	**Probability**
310.63	0.6359

Own production

The prior shows that macroeconomic and financial factors must be taken into account in inventory management, as proposed by Ray and Chaudhuri (1997), Teksan and Geunes (2016), Bulinskaya (2003), Hammoudeh and Yuan (2008), Ramírez and Manotas-Duque (2014); given that in the case of the EOQ for zinc importing companies in Colombia when the TRM drops, the EOQ increases due to the reverse causality between these two variables and that when crude oil prices increase, the EOQ is higher due to the relationship existing between these, according to what Cepeda-Jiménez (2016) and León-Orozco (2020) propose in their studies.

5. CONCLUSIONS

The objective of this study was to identify the effects of oil prices and the exchange rate on the EOQ for zinc importing companies in Colombia. For this purpose, autoregressive vectors (VAR) were used for the period between May from 2016 and May 2021. These results show that there is an inverse relationship between the EOQ and the TRM; this is due to the fact that a high exchange rate generates higher import costs and, in turn, reduces the purchasing capacity of companies. On the other hand, there is evidence of a positive relationship between the EOQ and oil prices. This is because of the fact that in Colombia there is an inverse relationship between oil prices and the exchange rate on many occasions, which allows an entry of currency thus devaluing the dollar and making imports cheaper.

The above shows how macroeconomic and financial factors can affect the supply chain as well as inventory management. Taking these results into account, investment risk analysis methodologies could be incorporated into inventory management, to carry out a prediction of the behaviour of macroeconomic and financial factors such as the TRM and the price of oil to identify the future cost of the inventory and thus carry out better management. Furthermore, future contracts can be made to mitigate the volatility of these variables.

Future research may be aimed at predicting the EOQ with different variables such as oil prices and the exchange rate with the use of tools such as autoregressive vectors, machine learning, and even differential equation models. This way future research can also contribute to the measurement of the impact of financial and macroeconomic variables in the different links of the supply chain, which would help to build more accurate inventory policies.

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REFERENCES

Almaraj, I.I., Trafalis, T.B. (2020), Affinely adjustable robust optimization under dynamic uncertainty set for a novel robust closed-loop supply chain. Computers and Industrial Engineering, 145, 106521.

Alshami, A.M., Muley, A. (2020), Economic ordering policy for VAR deterioration model with non-stationary two-warehouse inventory and demand. Prime: Indonesian Journal of Pure and Applied Mathematics, 2(2), 79-86.

Andriolo, A., Battini, D., Grubbström, R.W., Persona, A., Sgarbossa, F. (2014), A century of evolution from Harris's basic lot size model: Survey and research agenda. International Journal of Production Economics, 155, 16-38.

Ballod, R.H. (2014), Logística: Administración de la cadena de suministro. 5th ed. México: Pearson Educación.

Bergstrand, J.H. (1985), The gravity equation in international trade: Some microeconomic foundations and empirical evidence. Review of Economics and Statistics, 67(3), 474-481.

Candelo-Viafara, J.M. (2018), Impactos indirectos de la tasa de cambio y los precios del petróleo en una economía no petrolera: Aproximaciones VECM y VAR para el Valle del Cauca, Colombia. Revista Finanzas y Política Económica, 10(2), 403-436.

Candelo-Viáfara, J.M., Oviedo-Gómez, A. (2020), Efecto derrame del mercado Internacional en las economías latinoamericanas: Los casos de Chile, Brasil, Colombia y México. Apuntes del CENES, 39(70), 107-138.

Candelo-Viafara, J.M., Oviedo-Gómez, A. (2021), La tasa de cambio y sus impactos en los agregados económicos colombianos: Una aproximación FAVAR. Revista Facultad de Ciencias Económicas: Investigación y Reflexión, 29(2), 121-142.

Cepeda, Ó.M., Sánchez, L.F.J. (2016), Modelo de control óptimo para el sistema producción-inventarios. Ingeniería Industrial. Actualidad y Nuevas Tendencias, (16), 35-44.

Chen, F.Y., Ray, S., Song, Y.Y. (2006), Optimal pricing and inventory control policy in periodic-review systems with fixed ordering cost and lost sales. Naval Research Logistics, 53(2), 117-136.

Corden, W.M. (1984), Booming sector and Dutch disease economics: Survey and consolidation. Oxford Economic Papers, 36(3), 359-380.

De Truchis, G., Keddad, B. (2016), On the risk comovements between the crude oil market and U.S. dollar exchange rates. Economic Modelling, 52, 206-215.

Frenkel, R., Ros, J. (2006), Unemployment and the real exchange rate in Latin America. World Development, 34(4), 631-646.

Gilbert, C.L. (2010), Speculative influences on commodity futures prices 2006-2008. Geneva, Switzerland: United Nations Conference on Trade and Development.

Golub, S.S. (1983), Oil prices and exchange rates. The Economic Journal, 93(371), 576-593.

Gurtu, A., Jaber, M.Y., Searcy, C. (2015), Impact of fuel price and emissions on inventory policies. Applied Mathematical Modelling, 39(3-4), 1202-1216.

Hammoudeh, S., Yuan, Y. (2008), Metal volatility in presence of oil and interest rate shocks. Energy Economics, 30(2), 606-620.

Klibi, W., Martel, A., Guitouni A. (2010), El diseño de redes de cadena de suministro sólidas que crean valor: Una revisión crítica. European Journal of Operational Research, 203(2), 283-293.

Lanteri, L. (2012), Determinantes de los precios reales de las materias primas agrícolas. El papel de los inventarios y de los factores macroeconómicos (1960-2010). Lecturas de Economía, 77, 189-217.

León-Orozco, J.E. (2020), Análisis y Optimización del Abastecimiento, Demanda y su Impacto En los Inventarios de la Industria de Resinas Plásticas.

Mills, E.S. (1959), Uncertainty and price theory. The Quarterly Journal of Economics, 73(1), 116-130.

Mohr, E. (2017), Optimal replenishment underprice uncertainty. European Journal of Operational Research, 258(1), 136-143.

Montes de Oca, L.T., Rivera, D.N., León, A.M. (2018), Demands and limitations of the systems of information for the control of organizational management. Revista Universidad y Sociedad, 10(1), 8-14.

Perilla, J. (2011), El impacto de los precios del petróleo sobre el crecimiento económico en Colombia. Revista De Economía Del Rosario, 13(1), 75-116.

Petruzzi, N.C., Dada, M. (1999), Pricing and the newsvendor problem: A review with extensions. Operations Research, 47(2), 183-194.

Poncela, P., Senra, E., Sierra, L.P. (2016), Long-term links between raw materials prices, real exchange rate and relative de-industrialization in a commodity-dependent economy: Empirical evidence of "Dutch disease" in Colombia. Empirical Economics, 52(2), 777-798.

Ramírez, G.S., Manotas-Duque, D.F. (2014), Modelo de medición del impacto financiero del mantenimiento de inventario de suministros. Scientia et Technica, 19(3), 251-260.

Ray, J., Chaudhuri, K.S. (1997), An EOQ model with stock-dependent demand, shortage, inflation and time discounting. International Journal of Production Economics, 53(2), 171-180.

Reinhart, C.M. (1995), Devaluation, relative prices and international trade: Evidence from developing countries. IMF Staff Papers, 42(2), 290-312.

Rodríguez, J.M.M., Frías, C.S., Souquet, G.L.C. (2002), Administración de Riesgos Financieros: Un requisito necesario en la actualidad para ser competitivo. Revista Anales, 2(1), 87-97.

Santos, A.M.D., Rodrigues, I.A. (2006), Controle de estoque de materiais com diferentes padrões de demanda: Estudo de caso em uma indústria química. Gestão Produção, 13, 223-231.

Sims, C.A. (1980), Macroeconomics and reality. Econometrica: Journal of the Econometric Society, 48, 1-48.

Sinnott, E., Nash, J., De la Torre, A. (2010), Natural Resources in Latin America and the Caribbean: Beyond Booms and Busts? Washington, DC: World Bank Publications.

Teksan, Z.M., Geunes, J. (2016), An EOQ model with price-dependent supply and demand. International Journal of Production Economics, 178, 22-33.

Wilson, R.H. (1934), A scientific routine for stock control. Harvard Business Review, 13(1), 116-129.

Zuluaga-Mazo, A., Gómez-Montoya, R.A., Fernández-Henao, S.A. (2014), Indicadores logísticos en la cadena de suministro como apoyo al modelo SCOR. Revista unimagdalena. Clio América, 8(15), 90-110.