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# Presentation

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As a first article we present, *Socioeconomic stratification of coffee producing municipalities in Oaxaca integrated into the Crusade against Hunger*, by VÁZQUEZ-ELORZA Ariel, REYES-MUNGUÍA, Abigail and PARDO-NUÑEZ, Joaline, as next article we present, *Design of assessment instruments by competences for the operative personnel of an auto parts company*, por PÉREZ-RAMOS, María Gabriela, MERINO-MUÑOZ, Víctor Hugo, ORDAZ-CINTO, Angélica, TLAPALE-HERNÁNDEZ, Prudencio, as next article we present, *Empirical estimation of the volatility of the type of change in Mexico. A model of time series. 1995-2017*, by ROSAS-ROJAS, Eduardo, HERNÁNDEZ-CASTILLO, Yessica, BOLAÑOS-RAMOS, Samantha I. HUERTA-VEGA, Oscar I, as following article we present, *Forecast of the monetary base of Mexico. Algorithm of the box-jenkins methodology (1985-2015),* by ROSAS ROJAS Eduardo, ARIAS GUZMÁN Ericka Judith, GÁMEZ ARROYO Jessica, LAPA GUZMÁN Javier, GAVIÑO ORTIZ Gabriela.

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# Socioeconomic stratification of the producing municipalities of coffee in Oaxaca integrated to the Crusade against the Hunger

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## Abstract

Risks faced by coffee, such as problems in cultivation, production processes and price volatility, endanger the well-being of producers. To examine the problems of the coffee sector is required to approach it from a holistic approach and relate to various causes that may be inter-related. 5 as results main components explaining the cumulative variance of the variables in 74.29% were generated. the first two components accumulate 47.20% of the variability generated five layers for each of them are described. Oaxaca state maintains an important potential productive value (cultural) that must be valued in coffee producing areas framed in the crusade against hunger. It is therefore necessary to generate synergies between the triple helix (producers, government, business) generating scientific innovation, infrastructure and increasing human capital to support better public policies that achieve more value added to the coffee chain in underserved areas.

**Coffee, Analysis of Principal Components, Marginalization, Public Politics**

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## 1. Introduction

In the Mexican Republic, sixteen states produce coffee. Coffee production is concentrated in the states of Chiapas, Veracruz and Oaxaca, with more than 75 percent of producers, area sown and production volumes (Robles, 2011). In Oaxaca, where coffee plantations cover 24% of the total agricultural area of the state. The great paradox of coffee production in Oaxaca, is that although this contributes significantly to the entry of foreign currency to the country, practically a large number of coffee families live in extreme poverty (Avalos-Sartorio and Becerra, 1999).

The objective of this work was to investigate the characteristics of coffee producing municipalities in Oaxaca integrated into the Crusade Against Hunger, where socioeconomic, productive and marginalization aspects are related to establish strata of localities and locate lines of work in the design and implementation of public policies of the value chain. To do this, databases were used from the National Population Council (CONAPO), National Council for the Evaluation of Social Development Policy (CONEVAL), Food and Agriculture System of the Ministry of Agriculture, Livestock, Rural Development, Fisheries and Food (SIAP-SAGARPA).) and Secretary of Social Development (SEDESOL).

The methodology of Principal Component Analysis (PCA) was used to generate new uncorrelated variables from 15 variables on productive, socioeconomic and marginal aspects. Subsequently, the analyzed municipalities were stratified in homogeneous groups and heterogeneous among them.

## 3. Materials and Methods

The SIAP-SAGARPA, CONEVAL, SEDESOL and CONAPO databases were used to establish the stratification of the coffee producing municipalities in Oaxaca incorporated into the Crusade against Hunger. In the analysis of the information, 15 variables were related (see Table 1) that were selected according to socioeconomic conditions, productive characteristics of coffee and poverty. It is important to note that there are other variables that are also important and influential in the competitiveness of the coffee value chain; among them, there are the climatological ones that will be addressed in a later study.

| | | | |
|---|---|---|---|
| PPA | Percentage of population of 15 years or more illiterate | PPL | Percentage of population in localities with less than 5000 inhabitants |
| PVH | Percentage of homes with some level of overcrowding | PRO | Production (Ton) |
| POE | Percentage of occupants in dwellings without electric power | REN | Performance (Ton / Ha) |
| PPP | Percentage of population aged 15 and over without full primary education | VPR | Production Value (Thousands of Pesos) |
| PP2 | Percentage of employed population with income of up to 2 minimum wages | SCO | Sup. Harvested (Ha) |
| POA | Percentage of occupants in dwellings without piped water | SSE | Sup. Sown (Ha) |
| POD | Percentage of occupants in dwellings without drainage or toilet | GIN | Gini 2010 |
| | | PMU | Municipal Poverty 2010 |

**Table 1** Variables socioeconómicas, productivas y ambientales de estudio


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Continuing with the analysis of productive characteristics and marginality, in the Oaxacan coffee producing municipalities integrated into the crusade against hunger, the use of the Principal Component Analysis (PCA) methodology was considered with the purpose of generating new variables of components (eigenvalues - eigenvalues of each component) that summarize the characteristics of the studied problem of the original data set. The ACP reduces the dimensionality of the phenomenon by generating a baseline analysis of the original database and provides more information about the problem (Pla, 1986).

The purpose of generating new indicators, which relate various variables in 5 components, is based on a better contextualisation of problems in a holistic way, in the face of structural problems in the coffee sector. Once the components were obtained, we proceeded to stratify the first component obtained from the selected variables of coffee producing municipalities according to the productive, marginalization and socioeconomic characteristics of the municipality with the technique of Dalenius and Hodges (1959).

This tool helps reduce information by generating strata of municipalities in groups that are more homogeneous among themselves and more heterogeneous among them, considering minimizing the variance of the data under study. The results are intended to organize strata that guide the needs for the best design and implementation of public policies.

## 4. Results and discussion

According to the statistics of the SEDESOL, 1,012 municipalities are contemplated in the crusade relation against hunger. Among the main entities that have localities in these characteristics are:

Oaxaca which concentrates 28.8% (291 municipalities), Chiapas (6.9%, 97), Veracruz (8.4%, 85), Guerrero (7.6%, 77), Mexico (6.5%, 66), Puebla (6.3%, 64) and Michoacán (5.0%, 51). Of the total of municipalities in Oaxaca in the crusade against hunger, 42.6% (124) has a presence in coffee production, which demonstrates the direct relationship between rural municipalities with high marginalization and coffee crops as an important association. Of the 124 municipalities producing coffee in the crusade against hunger, 25.8% (32) have less than 2,500 inhabitants where they would be considered rural (according to the 2010 INEGI census), and 74.2% (92) are urban.

Table 2 shows the importance of the Costa Region in the planting of coffee with more hectares, mainly in Pochutla (32,138 hectares), which is also where the highest crop losses occur. It is important to note that the yield (ton / ha) is higher in the plantations located in the Sierra Norte region with 1.70 ton / ha, on average. Of course, there are soil conditions (soil and relative humidity of the environment) and climatology that significantly influence the productivity of coffee, which would be a work of further study to analyze. In rural areas, the average yield is 1.22 ton / ha while in urban areas they reached 0.99 ton / ha. The characteristics of coffee cultivation require more analysis according to the varieties in urban areas or producers without marginalization.

| Region | | Sur. Sown (Ha) | Sur. Harvested (Ha) | Average yield (Ton / Ha) |
|---|---|---|---|---|
| Cañada Region | 4to Distrito: Teotitlán | 16,380 | 16,315 | 0.85 |
| | 5to Distrito: Cuicatlán | 4,417 | 4,402 | 0.77 |
| | Total | 20,798 | 20,718 | 0.82 |
| Coast region | 21er Distrito: Jamiltepec | 1,871 | 1,786 | 0.45 |
| | 22do Distrito: Juquila | 10,339 | 10,159 | 0.36 |
| | 30mo Distrito: Pochutla | 32,138 | 30,178 | 0.41 |
| | Total | 44,348 | 42,123 | 0.41 |


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| | | | | |
|---|---|---|---|---|
| Isthmus Region | 28vo Distrito: Tehuantepec | 6,068 | 6,068 | 0.80 |
| | 29no Distrito: Juchitán | 2,785 | 2,785 | 1.38 |
| | Total | 8,853 | 8,853 | 1.03 |
| Mixtec Region | 16to Distrito: Tlaxiaco | 1,040 | 1,040 | 1.14 |
| | Total | 1,040 | 1,040 | 1.14 |
| Papaloapam Region | 6to Distrito: Tuxtepec | 6,608 | 6,054 | 1.25 |
| | 7mo Distrito: Choapam | 4,666 | 4,509 | 1.22 |
| | Total | 11,274 | 10,563 | 1.24 |
| Sierra Norte Region | 12do Distrito: Ixtlán | 766 | 766 | 1.80 |
| | 13er Distrito: Villa Alta | 2,186 | 2,186 | 1.78 |
| | 14to Distrito: Mixe | 11,843 | 11,603 | 1.63 |
| | Total | 14,795 | 14,555 | 1.70 |
| South Sierra Region | 15to Distrito: Putla | 7,155 | 7,155 | 1.09 |
| | 23er Distrito: Sola De Vega | 563 | 532 | 1.53 |
| | 26to Distrito: Miahuatlán | 6,836 | 6,835 | 1.42 |
| | 27mo Distrito: Yautepec | 1,498 | 1,498 | 1.39 |
| | Total | 16,052 | 16,020 | 1.34 |

**Table 2** Statisticians of the productive variables of the coffee of the municipalities in the crusade against hunger (2015)
*Source: Prepared by the authors with data from SIAP-SAGARPA (2015), SEDESOL (2015))*

The planted area and coffee production in the state of Oaxaca is differentiated by several regions (Cañada, Costa, Isthmus, Mixteca, Papaloapam, Sierra Norte, Sierra Sur) and classified into districts. As for production, the Mixe district accounted for 18.4% of the state total in 2015, followed by Teotitlán (13.4%) and Pochutla (12.1%). 51.61% of the municipalities producing coffee in the crusade against hunger are classified with high degree of marginalization (IMG) (64 municipalities), 47.58 with a very high IMG (59) and only 0.80% with low IMG (1) . The highest coffee yield is located in the municipality with low IMG, in contrast, municipalities with very high IMG have the lowest yields (0.97 ton / ha).

This reality reinforces that socioeconomic differences have a relationship with the scope of productivity capacities of the sector.

Table 3 shows 5 eigenvalues that show the percentage of variance explained by each one of them in the information set. The characteristic value associated with the first component summarizes 25.36% and the second 21.83%. The five components in the model explain 74.29% of the total variability of the information. On the other hand, with an approximate Chi-square value of 1.824.5 and 105 degrees of freedom and a significance of p = 0.000 it is evident that it is not an identity matrix and the ACP study can be carried out with the variables established in the table 1; in addition, the value of Kaiser-Mayer-Olkin (KMO) corresponds to 0.7 and therefore the model can be considered as acceptable

| Comp | Initial eigenvalues | | | Sums of saturations to the square of the extraction | | | Sum of the saturations to the square of the rotation | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total | % de la varianza | % acumulado | Total | % de la varianza | % acumulado | Total | % de la varianza | % acumulado |
| 1 | 3.805 | 25.364 | 25.364 | 3.805 | 25.364 | 25.364 | 3.700 | 24.666 | 24.666 |
| 2 | 3.276 | 21.838 | 47.202 | 3.276 | 21.838 | 47.202 | 2.261 | 15.074 | 39.739 |
| 3 | 1.775 | 11.832 | 59.034 | 1.775 | 11.832 | 59.034 | 2.143 | 14.286 | 54.025 |
| 4 | 1.151 | 7.675 | 66.709 | 1.151 | 7.675 | 66.709 | 1.578 | 10.520 | 64.545 |
| 5 | 1.137 | 7.583 | 74.292 | 1.137 | 7.583 | 74.292 | 1.462 | 9.747 | 74.292 |

**Table 3** Total explained variance of the main components
*Source: Extraction method: Principal Components Analysis*

Subsequently, we proceeded to correlate the five components with the variables of the municipal coffee producers of Oaxaca, which are also considered in the crusade against hunger. These are grouped with the independent variables (components) and according to their correlations in each of them.


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Table 4 shows the correlations between the variables under study and the five main components generated. When the associations between the variables are made, five very well defined groups are obtained. According to their classification the strata can be named as follows:

a. CP1 "Municipal coffee production of the municipalities in Oaxaca in the crusade against hunger".
b. CP2 "Poverty and marginality".
c. CP3 "Illiteracy and low income".
d. CP4 "Productive performance versus housing with energy and overcrowding".
e. CP5 "Housing characteristics (water and energy)".

| Typology | Variable | Component | |
|---|---|---|---|
| | | CP1 | CP2 |
| Percentage of population of 15 years or more illiterate | Pearson correlation | 0.05 | .188* |
| Percentage of population aged 15 and over without full primary education | Pearson correlation | 0.00 | .375** |
| Percentage of occupants in dwellings without drainage or toilet | Pearson correlation | -.251** | -0.09 |
| Percentage of occupants in dwellings without electric power | Pearson correlation | .311** | .426** |
| Percentage of occupants in dwellings without piped water | Pearson correlation | .236** | 0.02 |
| Percentage of homes with some level of overcrowding | Pearson correlation | 0.04 | .605** |
| Percentage of population in localities with less than 5000 hab. | Pearson correlation | 0.02 | .591** |
| Percentage of employed population with income of up to 2 SM | Pearson correlation | -0.14 | -0.05 |
| Sup. Sown (Ha) | Pearson correlation | .920** | -0.02 |
| Sup. Harvested (Ha) | Pearson correlation | .926** | -0.02 |
| Production (Ton) | Pearson correlation | .925** | -0.08 |
| Performance (Ton / Ha) | Pearson correlation | 0.01 | -0.04 |
| Production Value (Thousands of Pesos) | Pearson correlation | .919** | -0.09 |
| Gini 2010 | Pearson correlation | 0.16 | -.765** |
| Municipal Poverty 2010 | Pearson correlation | -0.17 | .759** |

| Typology | Variable | Componente | | |
|---|---|---|---|---|
| | | CP3 | CP4 | CP5 |
| Percentage of population of 15 years or more illiterate | Pearson correlation | .870** | -0.15 | 0.08 |
| Percentage of population aged 15 and over without full primary education | Pearson correlation | .845** | -0.08 | -0.06 |
| Percentage of occupants in dwellings without drainage or toilet | Pearson correlation | -.294** | -.200* | .587** |
| Percentage of occupants in dwellings without electric power | Pearson correlation | -0.04 | -.295** | .510** |
| Percentage of occupants in dwellings without piped water | Pearson correlation | .232** | 0.01 | .727** |
| Percentage of homes with some level of overcrowding | Pearson correlation | 0.09 | -.249** | .307** |
| Percentage of population in localities with less than 5000 hab. | Pearson correlation | -0.05 | .476** | -0.08 |
| Percentage of employed population with income of up to 2 SM | Pearson correlation | .478** | .271** | .438** |
| Sup. Sown (Ha) | Pearson correlation | -0.03 | -.277** | 0.02 |
| Sup. Harvested (Ha) | Pearson correlation | -0.02 | -.265** | 0.02 |
| Production (Ton) | Pearson correlation | 0.01 | .256** | 0.04 |
| Performance (Ton / Ha) | Pearson correlation | -0.10 | .879** | -0.10 |
| Production Value (Thousands of Pesos) | Pearson correlation | 0.01 | .259** | 0.05 |
| Gini 2010 | Pearson correlation | -.444** | 0.04 | 0.05 |
| Municipal Poverty 2010 | Pearson correlation | .287** | 0.08 | -0.10 |

** The correlation is significant at the 0.01 level (bilateral).
*. The correlation is significant at the 0.05 level (bilateral).

**Table 4** Pearson's correlation coefficient with the Component Matrix
*Source: Own elaboration with the methodology of Principal Components in SPSS*


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The first component (CP1) is highly correlated at the 0.01 level (bilateral) with the productive variables of coffee (planted area (ha), harvested area (ha), production (ton) and production value (thousands of pesos)) ; for what could be considered as "Municipal production of coffee of the municipalities in Oaxaca in the crusade against hunger." On the contrary, it presents a negative relationship with the percentage of occupants in dwellings without drainage or toilet.

The second component (CP2) is positively associated and the level 0.01 (bilateral) is significant with the percentage of dwellings with some level of overcrowding, percentage of population in localities with less than 5 000 inhabitants, municipal poverty 2010, which is I would call it "illiteracy and low income." In contrast, it presents a negative relationship with the Gini index. It should be noted that the highest inequality expressed in the Gini index is found in the municipalities with high levels of marginalization that average in 0.5664, in contrast, coffee producing municipalities with very high levels of marginalization have an average inequality of 0.5217 .

The third component (CP3) has a positive relationship between the percentage of the population of 15 years or more illiterate living in coffee producing regions in Oaxaca, percentage of population aged 15 years or older without full primary and percentage of employed population with income from Up to 2 minimum wages. In contrast, it presents a negative relationship with the percentage of occupants in dwellings without drainage or toilet and Gini index. This component may represent "Illiteracy and low income". The fourth component (CP4) presents a positive and significant relationship at the 0.01 level (bilateral) with the yield of coffee production; on the contrary, it has a negative relationship with the percentage of occupants in dwellings without drainage or toilet, harvested area (ha).

Percentage of occupants in dwellings without electric power and the percentage of dwellings with some level of overcrowding. This component could be considered as "productive performance versus housing with energy and overcrowding"; that is, the greater the production, the fewer problems related to housing services. Finally, CP5 is positively related to housing characteristics in water and energy.

Given that CP1 and CP2 collectively concentrate 47.20% of the variability of the information set, the two components obtained from the model will be considered for the analysis by means of the regression and standardization technique. In addition, the stratification of coffee producing municipalities according to the productive characteristics, marginalization and poverty of coffee was carried out using the technique of Dalenius and Hodges (1959). With this, the variance of the classes established on the territorial information of the coffee producing municipalities in Oaxaca (in the crusade against hunger) will be minimized, generating heterogeneous groups among them and homogeneous among themselves. The strata would focus the design of sectoral public policies for the coffee value chain and socioeconomic conditions of the local inhabitants' producers.

Once the strata were obtained, the first two components generated in the ACP model were linearly combined. For the first case, the standardized values of CP1 fluctuated between the values of -1,281 and 3,527. Applying the stratification of Dalenius and Hodges, the strata were segmented into the following interval limits of the first component: I. (-1.281, -0.319), II (-0.320, 0.161], III. (0.162, 1.123), IV (1,124, 2,565) and V. (2,566, 3,527) (Graph 1).


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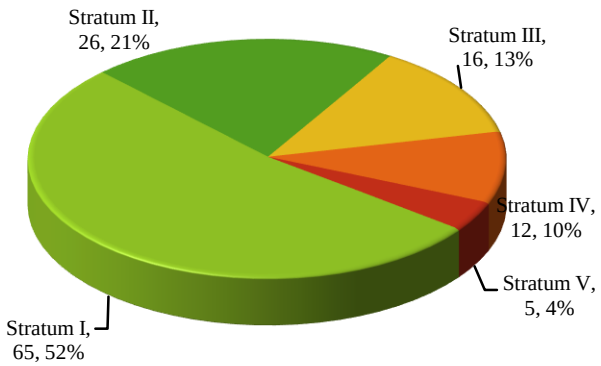
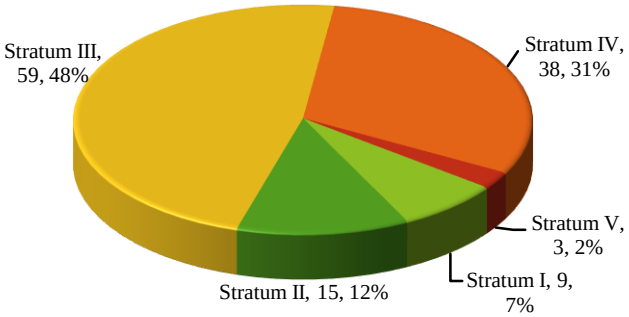
Thus, each municipality producing coffee in Oaxaca in the crusade against hunger is grouped under homogeneous conditions of the productive situation, marginalization and municipal poverty In the first stratum, there are 65 municipalities that represent 52% of the group analyzed with CP1, stratum II (26) represents 21%, stratum III (16) 13%, stratum IV (12) 10% and stratum V (5) 4%.




**Grpah 1** Municipal stratification of coffee production in CP1
*Source: Own elaboration, based on the indicators with the first component*

The second component (CP2) related to the poverty and marginality of coffee producing municipalities in Oaxaca (in the crusade against hunger) the limits fluctuated in: I. (-3.176, -1.611], II. (-1.612, - 0.568], III. (-0.569, 0.475], IV. (0.476, 1.519] and V. (1.520, 2.040] (graph 2 ) The Stratum I of CP2 concentrates 9 territorial coffee producing municipalities that represent 7% of the total (124), Stratum II (15) represents 12%, Stratum III (59) 48%, Stratum IV (38) 31% and Stratum V (3) 2%.




**Graph 2** Stratification of the characteristics of poverty and marginality in the coffee municipalities in the CP2
*Source: Own elaboration, based on indicators with the second component of the ACP*

Table 5 and 6 show the Stratums generated for both the first component (CP1) and the second component (CP2) and their relationships with the variables described in table 1.

| | Component 01 | | |
|---|---|---|---|
| Degree of Marginalization Very high | Stratum04 | Stratum05 | Total |
| Percentage of population of 15 years or more illiterate | 24.05 | 30.62 | 28.16 |
| Percentage of population aged 15 and over without full primary education | 48.94 | 49.30 | 48.80 |
| Percentage of occupants in dwellings without drainage or toilet | 0.52 | 1.73 | 2.39 |
| Percentage of occupants in dwellings without electric power | 11.04 | 12.42 | 6.99 |
| Percentage of occupants in dwellings without piped water | 16.69 | 39.74 | 18.44 |
| Percentage of homes with some level of overcrowding | 50.72 | 58.70 | 53.74 |
| Percentage of occupants in dwellings with dirt floors | 30.15 | 41.61 | 23.98 |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| | | | |
|---|---|---|---|
| Percentage of employed population with income of up to 2 minimum wages | 60.14 | 74.41 | 70.87 |
| Performance (Ton / Ha) | 1.01 | 0.67 | 0.97 |
| PMR ($ / Ton) | 3,935.75 | 4,167.33 | 3,889.84 |

**Table 5** Characteristics of the CP1 with IMG Stratums Very high
*Source: Own elaboration with data from SIAP-SAGARPA (2011) and CONEVAL (2015)*

| | Component 02 | | | | | |
|---|---|---|---|---|---|---|
| Degree of Marginalization Very high | Stratum 01 | Stratum 02 | Stratum 03 | Stratum 04 | Stratum 05 | Total |
| Percentage of population of 15 years or more illiterate | 31.19 | 27.74 | 27.98 | 28.37 | 26.12 | 31.19 |
| Percentage of population aged 15 and over without full primary education | 44.45 | 46.58 | 47.56 | 50.40 | 43.38 | 44.45 |
| Percentage of occupants in dwellings without drainage or toilet | 1.14 | 0.87 | 3.35 | 1.97 | 1.33 | 1.14 |
| Percentage of occupants in dwellings without electric power | 3.69 | 3.09 | 5.67 | 8.03 | 12.79 | 3.69 |
| Percentage of occupants in dwellings without piped water | 31.81 | 15.79 | 20.56 | 17.75 | 3.11 | 31.81 |
| Percentage of homes with some level of overcrowding | 52.66 | 42.14 | 50.13 | 57.31 | 56.04 | 52.66 |
| Percentage of occupants in dwellings with dirt floors | 28.10 | 27.38 | 20.45 | 25.84 | 26.82 | 28.10 |
| Percentage of employed population with income of up to 2 minimum wages | 71.13 | 83.19 | 73.59 | 69.23 | 47.79 | 71.13 |
| Performance (Ton / Ha) | 0.80 | 0.93 | 1.00 | 0.93 | 1.48 | 0.80 |
| PMR ($ / Ton) | 4,388.30 | 4,252.15 | 3,959.38 | 3,815.21 | 3,488.93 | 4,388.30 |

**Table 6** Features of CP2 with IMG Stratums Very high
*Source: Own elaboration with data from SIAP-SAGARPA (2011) and CONEVAL (2015)*

## 5. Conclusions

Of the 2,458 that exist in the country, the state of Oaxaca is the main entity with municipalities in the Cruzada Contra el Hambre (291), concentrating 28.8% of the country's total. Of this total, 124 municipalities have coffee activity mainly inhabited with levels of high and very high marginalization; 25.8% (32) have less than 2,500 inhabitants (rural), and 74.2% (92) are urban. The value of coffee production in rural municipalities represents around 40% of the total value of total agrifood production, and in the case of urban municipalities, 24%.

For practical purposes, the components for the analysis were considered since they incorporate about 50% of the variability of the information that explains the municipal coffee production of the municipalities in Oaxaca in the crusade against hunger, as well as poverty and marginality respectively . The third component is related to illiteracy and low income, the fourth with productive performance versus housing with energy and overcrowding, and the last one with housing characteristics (water and energy).

The yields and productions of coffee in the municipalities of the crusade against hunger in Oaxaca do not behave equally between rural and urban regions. This situation is positively related to the socioeconomic situation and marginality in which the inhabitants of the value chain live.


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There are other important factors such as environmental, pedological, safety, quality and socialization networks of technological packages that will be addressed in a post-erior study. The producing municipalities must incorporate public policy actions that involve innovations in the production and marketing processes in order to add value to the final product to the consumer.

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# Design of evaluation instruments by competences for operative personnel of an autoparts Company

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**Abstract**

The article briefly describes the process of designing and applying competency assessment tools for an auto Parts Company, starting from the matrix of competencies defined and approved previously with the organization. The results of stage II, of the pilot project of Competency Certification for operational personnel for grinding line CNC are presented. It is worth mentioning that the first stage was already presented in the previous edition of the CICA 2016 congress.

Objective: Develop and apply evaluation instruments for the scheme of certification of labor competencies to operational personnel in an auto parts company.

Methodology: Analysis of the labor competence, of the units of competence, design of evaluation instruments in the three knowledges: Knowing to do, to know, to know to be. Application and analysis of results of the evaluation to deliver the project.

Contribution: The results of stage 2 of the pilot project made it possible to make the diagnosis of the level of labor competencies to personnel considered as experts in the management of Línea de rectificado CNC, and through them identify opportunities for improvement to standardize and improve the manufacturing process, to meet specifications Quality and competitiveness. As well as increasing the competence of the operative personnel that will allow to improve indicators of Volume, Cost, Quality and Industrial Safety

**Evaluation by labor competencies, evaluation instruments**

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## 1. Introduction

Currently the evaluation for labor competencies plays a very important role, since it is through this process that organizations have the possibility to ensure that their staff is trained to perform the tasks required in their jobs. Hence the importance that an auto parts company is in an evaluation process to technical staff and in the future it is expected to have a program to obtain labor certification for its operational staff, so it made an agreement with the Technological University of Huejotzingo to develop the pilot project of Certification of operators in a CNC grinding line.

In Pérez, De Ita. Velázquez and Fernández (2016), the first stage of the project is described, which defined the competence that the operators must have for the preparation, operation and execution of the model change in the CNC Grinding Line, as well as the management of the production process, derived from these results were proposed certification levels by competencies, as well as the proposal of a training plan.

This second stage consisted of developing evaluation instruments by competences of the process of operation of the CNC grinding line in the three areas of knowledge: Knowing how to do, knowing, knowing how to be. This allowed us to identify the level of competence in which the expert technicians who currently operate the machine are.

As mentioned in Pérez, De Ita. Velázquez and Fernández (2016), the objective of the project developed with the company is mainly that the operating personnel execute their production activities according to an individual work role, with the level of competence required, so that they are capable of making decisions and propose solutions to the problems of day-to-day production."

It is important to clarify that due to confidentiality issues the name of the company will not be mentioned throughout the article, and the results that are exposed are a brief extract of those delivered to the company, however you have the authorization to carry out the same.

### 1.1 Justification

Stage II is part of a large pilot project that will allow the company to replicate it in other work stations of the plant and achieve that the company generated an evaluation scheme for labor competencies and provide incentives to personnel that contribute to the achievement of their organizational objectives . Therefore, the design, as well as the application of evaluation instruments carried out in stage II, to the expert personnel in the short-term CNC grinding line is: Identify the current level of competence acquired with the scheme proposed in stage 1 of the project and readjust the training plan proposed in it.

Long-term: The standardization and improvement of manufacturing processes, to comply with strict quality controls for competitiveness

The acquisition of the competence of the operating personnel will improve indicators of Volume, Cost, Quality and Industrial Safety.

### 1.2 Problem

Currently the company has an evaluation scheme for knowledge on the management of technical documentation that applies to different production lines and in some cases knowledge of the process. This prevents the objective evaluation of a competence in its three levels of action: know-how (technical / practical application), knowledge (theoretical) and knowledge to be (teamwork, communication, respect, etc.).


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The results of stage I have been described briefly in the previous paragraphs and it is from them that the main problem now lies in defining the types of evaluation instruments that should be designed and applied to two protagonists of the process, who are considered As experts, since it is still a pilot project, the above will allow to identify the level of competence that they have reached in the operation of the machine, the management of the process and the release of the product. With the results, the company will have an overview of the strengths and weaknesses to start the training stage and in the future apply the evaluations to the rest of the CNC grinding line personnel.

So this article describes the background of the evaluation by competencies and its current importance in companies. And the development process in the methodology applied in this second stage of the pilot project of the CNC grinding line, as well as a brief description of the results obtained.

### 1.3 Objectives

#### 1.3.1 General Objective

Design and apply evaluation tools by competencies to operational personnel of the CNC grinding line for the pilot project of certification of labor competencies in an autoparts company.

#### 1.3.2 Specific Objectives

- Analysis of the competency matrix
- Selection and design of evaluation instruments
- Application of the instruments by competences
- Analysis of the results of the evaluation.
- Delivery of results and project validation by the company

## 2. Theoretical framework

### 2.1. Evaluation by labor competences

Before entering the evaluation process by competences, it is important to return to some definitions of competences: in Flores (2007); Echeverría, (2002), mentions that professional competence is the sum of four components; the subjects know (technical competence), know how to do (methodological competence), know how to be (personal competence) and know how to be (participative competence).

For Flores (2007), Identifying specific competencies in a job is a fundamental stage for human resources management; which is fundamental for the description of the jobs of a company. The description of the competency profile of the job is a common reference to perform the competency assessment.

The Council for Standardization and Certification of Labor Competence (CONOCER) of Mexico defines a competence as the productive capacity of an individual, who is defined and measured in terms of performance in a specific work context, not only knowledge, skills, attitudes; these are necessary but not sufficient by themselves for effective performance. "The standard of competence: are the knowledge, skills, skills and attitudes required, for a person to perform any productive, social or government activity, with a high performance level, defined by the sectors themselves". (KNOW, 2009)

However, the competences must be evaluated to determine the level of competence reached. The Association to Improve the Transparency of Qualifications in Spain (EVA, 2008), mentions that in the current environment organizations are more interested in the know-how demonstrated in the development of work activities.


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So for a management of the skills required in the work instruments of identification, evaluation and recognition of them are required, considering that the design of these is limited to the validity of the organizations, the above by the specific needs of each organization. For the EVA (2008), the evaluation means "checking the competences of a person with respect to a given referential. That is to say what, how and for what is going to be measured. They must identify: the method and tools to be used, designate the protagonists, specify the effects of the evaluation and agree on "rules of the game".

In Alles (2007), a management model based on competencies is based on three subsystems: selection, so that, starting with the start-up, people with the desired competencies can enter; performance evaluation, to know the degrees of competences of each member of the organization; and the fundamental, the development of them.

## 2.2 Evaluation process

In agreement with CINTERFOR (2009), in the document Methodology for the evaluation by labor competences, the evaluation by competitions like tool for the certification; is a process that allows the collection of evidence about the work performance of the person evaluated, according to the specifications established in technical standards of Labor Competence (NTCL), and through this will determine the level of competence that has the evaluated in the performance of a certain job function.

Additionally, in the labor competency evaluation manual of the National Council for Standardization and Certification of labor competencies (CONOCER, 2007) 5 stages are mentioned in the evaluation process:

| Stage | Description |
|---|---|
| Determine evaluation techniques and instruments on job competency of candidates based on Labor Competency Technical Standards (NTCL). | In this stage you should:<br>• Identify evaluation contents of the UCL<br>• Select evaluation techniques and instruments for the identified contents. |
| Determine labor competency assessment plans (CL) | • Structuring evaluation plans. Presentation and agreement of evaluation plans with the candidates. |
| Integrate evidence portfolios of candidates for CL certification | • Application of evaluation instruments.<br>• Verification of the authenticity of historical evidence.<br>• Organization of the documentation contained in the evidence portfolio. |
| Issuing judgments of the CL to candidates for labor competency certification. | It is a procedure to obtain the result of the evaluation based on:<br>• The comparison between the collected evidence and the corresponding UCL.<br>• The preparation of the evaluation card. |
| Guide candidates in relation to the result of their evaluation of labor competencies | Point out the procedures for:<br>• Guide the candidate based on the result of his evaluation.<br>• Prepare the orientation report. |

**Table 1** Stages of the evaluation process
*Source: Conocer. (2007)*

## Background of the Grinding Line project CNC stage II.

The auto parts company with which the researchers of the Technological University of Huejotzingo (UTH), developed the pilot project during stage I, consisted in determining the competence that the operators of the CNC grinding machine should achieve. Based on the results obtained from the analysis and standardization of the operations, the competence matrix was generated, in which a competence and two competence units were determined, as well as 14 capacities; each one with its corresponding performance criteria.


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The results can be consulted in Perez, De Ita, Velázquez and Fernández. (2016). It is important to emphasize that reasons of confidentiality the results can not be exposed in full.

## Methodology

The process of execution of the project is summarized in figure 1. Which is closely related to the stages of the process of evaluation of CONOCER, however the results and feedback to the evaluated personnel was carried out by company personnel.

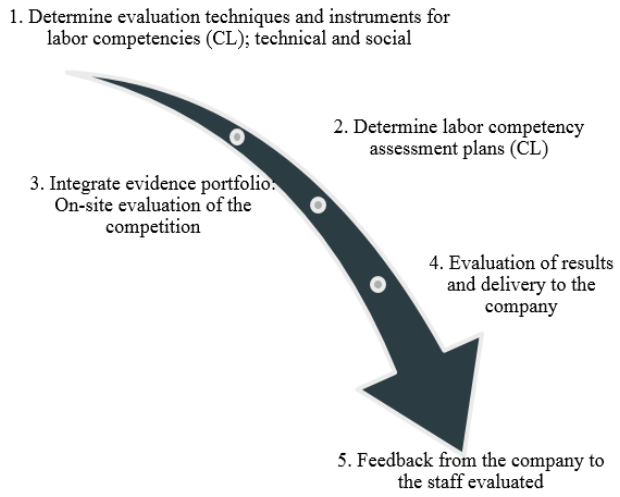


**Figure 1** Process of project execution
*Source. Own elaboration, from CONOCER. (2007)*

## Problem

Identify evaluation contents of the labor competency units to select the evaluation techniques and instruments according to the defined competence: Manage online production to ensure the quality of the process and the product in the set-up for the operation and contribute to the competitiveness of the company.

## Investigation questions

What is the competition to evaluate?
What are the units of competencies to evaluate?
What assessment instruments should be applied?
What needs for technical training is required to ensure the delivery of quality products?

## Instruments

Technical documentation of the machine and the process, formats for the design of evaluation instruments: questionnaires, observation guides, checklists and results summary formats.

## Project execution process

Once the execution plan of stage 2 of the project was approved, the group of researchers of the UTH, began with its execution, according to the stages described in the figure 1.

**Stage 1**. Determine the evaluation techniques and instruments to determine the level of labor competency (CL) achieved: Basic, Operational and autonomous, as well as the necessary social competences.

The previously approved competence was analyzed, as well as the two units of competence and the 14 capacities as well as their corresponding performance criteria, the previous allowed the grouping of the levels of competence for each of these, result of stage1.

The two units of competence are: the execution of the change of model and the execution of the product in compliance with the requirements of the client. Additionally, the social competences that the company promotes must be considered: team work, decision making, among others.


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**Etapa 2**. Determine the evaluation plan. It consisted in defining: what, how, where, who would be the operators evaluated, with what instruments would be evaluated which process, who would carry out the evaluation of the candidates based on the selected techniques and instruments. The above was previously validated with the company.

**Stage 3.** Integrate evidence portfolio: Evidence was collected to issue the evaluation judgment. The UTH researchers recorded the information in the evaluation instruments based on performance and products. Ensuring that at the time of the evaluation the required instruments will be available. Considering the sequence of the activities to be developed (what) and the form of development (how) and informing the evaluated the process to which he would be subjected, in such a way that his performance was the daily one in his working day.

**Stage 4.** Evaluation of results and delivery to the company, with the corresponding evaluations of each technician, the reagents were identified with the information corresponding to each performance criterion, as well as the evidence of knowledge. Registering the number of reagents assigned to each performance criterion and the evidence of knowledge of each one of the evaluation contents to determine the competence reached.

**Stage 5.** Feedback from the company to the evaluated personnel. This phase of the project was assumed by the company, because they consider the feedback from their area managers as a process of continuous improvement.

## 4. Results.

Below is an extract of the results obtained:

Stage 1. Determination of instruments according to the units of competences, capacities and performance criteria. Table 2 summarizes the type of instruments developed according to the required characteristics.

| Unit of competence | Capacities | Performance criteria | Evaluation instruments designed |
|---|---|---|---|
| Execute model change of considerations for the process and product, to reduce variation and comply with the production plan. | Prepare tooling change | Select and value tooling, gages according to the model | Observation guide, and knowledge evaluation, check lists. General data to include: performance criteria, types of evidence name of the evaluator, name of the evaluated. |

**Table 2** Example of unit of competence analysis to select evaluation instrument.
*Source: Adaptation based on results stage 1 of the pilot project*

### Stage 2. Determine evaluation plan

As a summary of this stage it can be mentioned that the company approved the evaluation plan and determined who should be evaluated, the UTH researchers defined who would apply the instruments according to the activities that make up the sequence of operations of the evaluated process

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It was defined: The process that would be evaluated, data of technical personnel and evaluators. The activity to be developed (what), the form of development (how), the evaluation technique and instruments (with what), the place of the evaluation (where), dates of evaluation according to the plan, names and signatures of the evaluated and the candidate.

**Stage 3. Integrate evidence portfolio**

As a summary, it is mentioned that the model change competency unit is: the place of evaluation was at the plant, during the work schedule of the candidate evaluated, on the dates agreed with the company and with the labor performance observation guides. in the execution of the change of model, according to the capacities and performance criteria that the evaluated technician had to show.

For example, for the performance criteria in Table 1, the criteria evaluated consider knowledge and management of Master and gages for measurement according to the control plan, (includes the interpretation of the control plan, characteristics to be measured, etc.) availability of the main disk (the location and assembly of prisms). Additionally, knowledge assessment tools for control plan, tolerances, among others, were carried out. The same happened for the 14 evaluated capacities. At the end of the UTH team compiled the information obtained, made the report of the evaluations of labor, social and relevant knowledge, to concentrate all the results and issue the opinion.

**Stage 4. Evaluation of results and delivery to the company**

As an example, an extract of the results obtained by one of the technicians evaluated is presented. We considered 58 items evaluated in the preparation, execution of the change of model, as well as the management of the production.

Obtaining correctly 55, with which it reached a level of autonomous competence. Must take care of the following aspects: The measuring instrument must be in operating conditions; with updated calibration dates, validate safety conditions of the equipment to mobilize the tooling of the machine and ensure the gages before the production process.

**Stage 5. Feedback from the company to the evaluated personnel**

This stage the company considered that it was their responsibility to inform the people evaluated, since they can provide a more direct feedback on the areas of opportunity to improve. To finish with the results obtained, the restructuring of the courses for basic, operative and autonomous level was continued. To date the Technological University of Huejotzingo continues to work with the company to train new staff.

**5. Conclusions**

The evaluation by labor competences is a tendency that the companies are assuming to assure that their personnel is competent in the performance of their activities allowing to assure the quality of the products and services that it provides.

Therefore the work developed with the company; allowed to meet the objectives set. The UTH team designed evaluation instruments for the personnel that operates the CNC grinding line, of competence level: Basic, Operative and autonomous.

The results for diagnostic purposes allowed identifying training needs in some theoretical aspects such as the interpretation of plans, the management of computer systems of the company, general issues such as control of inventories and knowledge of travel cards for each process, among others.

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At the end of the project, the company considered that the number of reagents was sufficient, with an adequate level of depth depending on what was required to evaluate, and it is considered relevant to validate the evaluation instruments before their application to standardize the technical language.

Finally, derived from the grouping of knowledge in the matrix of competences and the results of this second stage, the adequacy of the training project for all the operative personnel of the company arose, in which at the date in which this report is presented they have participated in the design and delivery of specialized courses for active personnel, as well as new teachers from UTH careers related to the company process.

**Acknowledgment**

We appreciate the support received from the company, its administrative and engineering areas, who were responsible for the management and the project; for their interest in continuous improvement for the benefit of achieving the objectives and consequently of the human capital that integration. A special thanks to the Director of the company for the trust placed in the University, as well as to the technicians who participate in the pilot test; Who focuses on the evaluation process.

Finally, all staff and students of the Technological University of Huejotzingo, who have participated directly and indirectly in the project to meet the objective.

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# Empirical estimation of the volatility of the exchange rate in Mexico. A model of time series. 1995-2017

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## Abstract

The present research aims to provide a relevant algorithm for the proper identification of a data generating process (economic and financial variables) by using the "auto.arima" command, belonging to the forecast library (R statistical software), to identify the optimal parameters of the ARIMA model. Considering the methodological framework of Box and Jenkins process (1970), it seeks to achieve, by solving a stochastic difference equation, the correct calibration and obtaining an optimal forecast for the Mexican Monetary Base, one of the main economic variabes.

**Forecast, Monetary Base, ARIMA Models**

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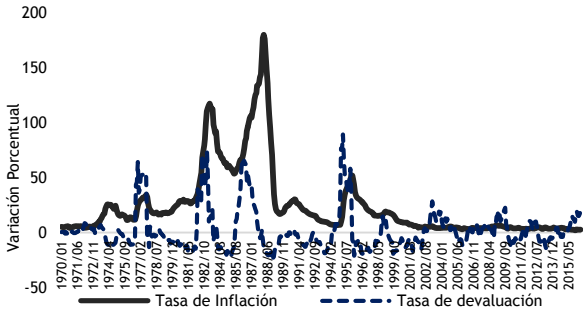
## I. Introduction

In Mexico, reforms have been undertaken in favor of economic and financial liberalization with the objective of taking advantage of globalization. These reforms began in the 1980s with the adoption of the neoliberal model that included the deregulation and opening of financial markets and less State intervention. Throughout the 1990s, these reforms accelerated and deepened the process, which led the country to greater integration into the world economy.

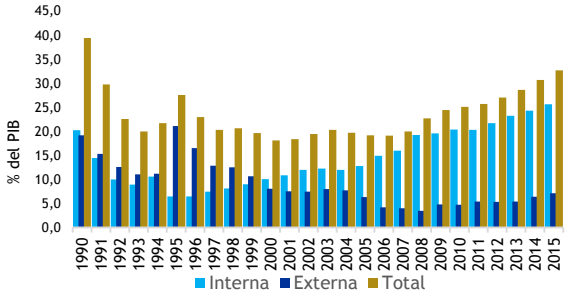
In an increasingly international environment, advantages have been generated for countries, fostering an increase in foreign investment flows to developing countries, the reduction of tariffs on trade, the creation of large financial innovations (derivatives and securitization), others But deep economic instability has also been fostered by being more exposed to external changes, the opening of markets has produced a sustained increase in both trade relations and in the circulation of capital, the problems of financial supervision have been become much more complex and the handling of the exchange rate has become increasingly relevant because of its effects not only in the domestic economy but in the international financial system.

According to Caballero R. and Caballero (2016), fluctuations in the exchange rate have acted as a channel for contagion of international crises to countries, as the effects of these crises deepen when countries have a strong trade opening high pass-through of the exchange rate towards domestic prices (graph 1), and dollarization of its liabilities ( graph 2). In this regard, Mexico exhibits all three characteristics, which indicates that exchange rate instability may continue to be a transmission mechanism, since exchange volatility continues to be an important element for any economic activity that involves international exchanges.

Whether physical assets and / or financial, in this sense remember the "Tequila Effect".




**Graph 1** Magnified transfer of the exchange rate to inflation in Mexico. 1970-2015
*Source: Own elaboration with data obtained from INEGI*




**Grpah 2** Composition of public debt in Mexico (1990-2015)
*Source: Own elaboration with data obtained from INEGI*

There are several exchange rate regimes that the Mexican economy has experienced, however, it has been argued that exchange rate flotation systems can be more risky than fixed systems, since they imply greater volatility since they change continuously; This is because they are determined by their supply and demand, and are more exposed to structural changes and / or external shocks that cause uncertainty and which in turn affect investment decisions because they generate risks for companies and individuals (Ortiz et al, 2011). Some of the events that have impacted the volatility of the exchange rate are mentioned below: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a. Devaluation in 1994: Mántey (2009) argues that a common denominator that gave rise to this crisis was mainly the maintenance of an exchange anchor that overvalued the Mexican peso excessively.

b. Crisis of the Asian tigers 1997: Due to the strong speculative attacks, strong devaluations of the currencies were provoked, as a result the Asian countries set aside the fixed exchange rate regime to implement a free float exchange rate.

c. Russian debt 1998: "The government and the central bank of Russia repudiated the payments on the internal debt, announced a moratorium on private external debits and abandoned the ruble to their fate" (Bracho, 2000). This caused the breakdown of most major banks, a sharp devaluation, the fall of the Stock Exchange, the interruption of all external capital, among others.

d. Crisis of the Brazilian Real (1999): The fragility of Brazilian public finances and the moratorium declaration of the Gerais mines on January 6, 1999 caused the depletion of Brazilian reserves and the federal government had no alternative but to devalue.

e. Crisis 2001: It was due to the deceleration of the North American economy through the so-called "dot com" crisis.

f. Crisis of 2008: Low interest rates in the 2001-2006 period led to easy and cheap loans. The banks found new businesses in the conversion of consumer debt into marketable securities.

g. The electoral triumph of Donald Trump (2016): After Trump's victory, the peso fell by more than 13%. It went from 18.5 per dollar to 20.74 per dollar. This is explained by the economic dependence so marked with the United States. With the entry into force of NAFTA, Mexico boosted the level of exports to its main trading partner (United States), but in turn increased its dependence on this country.

Thus, in an international context marked by the consequences of the financial and exchange crises and the fact that the exchange rate is one of the main channels for the transmission of inflation in developing countries, it has led to several central banks, mainly emerging economies to adopt inflation targeting (MI) schemes for the conduct of their monetary policy. These propose, among other aspects, that free market forces determine the exchange rate, where monetary policy is responsible for ensuring price stability by regulating aggregate demand through the interest rate and leaving aside the rate of interest change as nominal anchor.

However, although it has been argued that the exchange rate as a nominal anchor was left behind, this argument continues to be questioned, because although the formal instrument to impact on price stability is the interest rate, the The change in the Mexican peso has been key in the process of convergence of inflation (Mántey, 2009). Generally speaking, flexible exchange rates have led to an accelerated increase in real exchange rates and, as a result, have led to a consequent transfer of inflation to domestic prices, which has weakened investment and sustained economic growth.

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This is the reason why the main Latin American economies seek at all costs to meet the objectives of inflation targets, and for that purpose it uses the exchange rate as a nominal anchor "(Rosas, 2016). This means an implicit recognition by the Bank of Mexico that the exchange rate is the main transmission channel of inflation; hence the "fear of floating" (Calvo and Reinhart, 2002).

The inflation targeting monetary policy scheme was used for the first time in 1990 by New Zealand and from then on, several countries, both developed and emerging, including Mexico in 2001, chose to adopt this scheme. Inflation goals "are a framework of monetary policy characterized by the public announcement of official quantitative targets for the rate of inflation in one or more time horizons, and by the explicit recognition that low and stable inflation is the main objective of the long-term monetary policy "(Hüfner, 2004). With the implementation of this model, the inflation rate in Mexico has effectively decreased (Figure 1), but it has left aside important aspects in the economy such as growth and unemployment.

Thus, the objective of this research paper is to analyze and estimate a measure of exchange rate volatility for Mexico in the period 1995-2017 with daily data using the family of GARCH models. This is due to the fact that exchange volatility continues to be a transcendental element for any economic activity that involves international exchanges. Also, the study period is interesting, since it involves periods of high exchange volatility accompanied by global economic and financial crises The document is organized in 4 sections in addition to this introduction. The first refers to the review of the literature; the second shows the theoretical framework on the main stochastic models of volatility; in the third the econometric methodology is shown and in the last section the results are explained and the conclusions are presented.

## 2. Review of Literature

Since Engle in 1982 proposed to model the heteroscedastic nature of the time series using the ARCH models, the door was opened for the modeling of the exchange rate. Subsequently Bollerslev in 1986, due to the large number of parameters required by the ARCH models, raises the models known as GARCH.

The studies that analyze the transmission of volatility were initiated by Engle in (1990) and continued with Bollerslev (1990), Kearney and Patton (2000), Speight and McMillan (2001), among others. In all these studies, GARCH models were used to study the relationship between volatilities.

There are numerous studies that analyze the volatility of the exchange rate using GARCH models. In the case of Latin America, some studies focus on univariate models, namely, Grajales (2006), Carranza and González (2009) and Aranda, et. al in 2012. In 1998, Aragón and Atilano analyzed the effect of the type of regime in Mexico for the 1986-1998 period and concluded that in a flexible exchange regime, the estimation of a GARCH (1, 1) allows correctly model the volatility of the exchange rate, however its determinants must be analyzed to explain the violent changes and currency revaluations.

Viales (2010) uses historical GARCH series and concludes that the volatilities of Latin American countries are similar. On the other hand, Castaño, et al. (2006) present a work in which they calculate the term structure and the multi-period volatility of the Colombian peso, with the objective of knowing market expectations about the volatility of returns, in different time horizons. Aranda et. al (2012), compares various modeling alternatives, concluding that the GJR-GARCH model is the most adequate to forecast volatility at different horizons in Mexico.

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Finally, although there are more studies, Bello in 2013 estimated the "value at risk" (value At Risk) from models GARCH, Zumaquero and Rivero (2010), analyze the structural changes and the behavior in the real exchange rate for a set of OECD countries during the period 1960-2006 in which they suggest that there is clear evidence in favor of the non-neutrality of the nominal exchange regime on the volatility of the real exchange rate for developed countries, but not in the case from developing or emerging countries.

In the case of Mexico, in 2009 Banco de México carried out a forecast of the volatility of the exchange rate and concluded that the best forecast is obtained when combining an ARCH forecast and an implied volatility forecast in options using weights that change over time. In 2012, Ortíz, et. they developed a forecast of exchange volatility using GARCH models, in which they evaluated the ability of two model specifications to forecast the volatility of the exchange rate between the Mexican peso and the United States dollar; with this they came to the conclusion that it is not possible to affirm that the assumption of normal errors is the best specification to efficiently forecast the exchange volatility. What can be said is that this specification could be adequate enough to be used for the purposes of managing foreign exchange risk.

In 2016, R. Caballero and Caballero analyzed the evolution of exchange rate volatility in Mexico and Brazil and presented evidence that it tends to decrease over time. In addition, they arrive at the following results: a greater exchange depreciation temporarily precedes a higher exchange rate volatility; once the volatility is in a certain regime (high or low), the possibility of passing to another regime immediately is very low, and finally, there is a high persistence of volatility in both economies (p.1).

## 3. Theoretical Framework

In 1970, Box and Jenkins amalgamated the ideas about the deterministic time series of Yule (1927) and introduced the stochastic component; these ideas formed the basis of a coherent and versatile approach that identified the iterative cycle of the series in three stages: identification, estimation and verification of the diagnosis. On the other hand, the volatility of the time series is an issue that for several decades has attracted the interest of researchers in the financial area. The seminal works of Engle (1982), Bollerslev (1986) and Taylor (1986) were the basis for the construction of a growing theoretical frame of reference for modeling conditional autoregressive heteroskedasticity.

In conventional econometric models, it is assumed that the variance of the error term is constant. However, many of the time series in the economy show periods of high volatility followed by relative tranquility. Under these circumstances, the assumption that there is a constant variance, that is to say that it is a homoscedastic series, is wrong. Given that the mean and the conditional variance have a lower bias than their non-conditional counterparts, they are preferable for the development of forecasts. The residuals of a GARCH model can come from an ARIMA model or a multiple linear regression model, so there are multiple possibilities for the construction of a hybrid model. Thus, the ARIMA and GARCH models are an essential tool for modeling the volatility of a very important economic variable, such as the exchange rate.

### ARIMA Model

It is possible to combine a process of moving averages with a linear difference equation to obtain an autoregressive model and moving averages (ARMA). In these models it is perfectly permissible that the length of both processes be infinite. Consider the following representation:


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$$Y_t = a_0 + \sum_{i=1}^{p} a_i Y_{t-i} + \sum_{i=0}^{q} B_i E_{t-i} \quad (1)$$

To ensure that an autoregressive econometric model is stable, that is, converges, the following rules must be met (Enders, 2015: 31).

1. In a n-th order equation, a necessary condition for all characteristic roots to fall within the unit circle is:

$$\sum_{i=1}^{n} a_i < 1$$

2. Since the value of a_i can be positive or negative, a sufficient condition for all characteristic roots to fall within the unit circle is

$$\sum_{i=1}^{n} |a_i| < 1$$

If one or more of the characteristic roots of (1) is greater than or equal to the unit, the sequence {Y_t} is known as an integrated process and in this case the model is called Integrated Self-Regressive Moving Averages (ARIMA) (Enders, 2015:50). In this situation the time series becomes unstable, and its modeling can not be performed, because the function tends to infinity. This type of process is also known as "non-stationary". And some algebraic transformation must be applied that makes them stationary.

It is said that a series of time is stationary in a broad or weak sense, if and only if it satisfies three conditions:

- The average is constant over time. $E(Y_t) = E(Y_{t+T}) = \mu \ \ \forall T \in \mathbb{R}$.
- The variance is constant over time. $Var(Y_t) = Var(Y_{t+T}) = \gamma \ \ \forall T \in \mathbb{R}$.
- The autocorrelation function is independent of time. This measures the possible dependence between an observed value $(Y_t)$ and other $(Y_{t-k})$ which is separated by a length interval $k$.

When the appropriate transformations have been made so that the time series is stationary, the development of the Box-Jenkins methodology can proceed. The ARIMA methodology, as it is also known, consists of the following stages:

a. Identification of the Tentative Model. The simple and partial correlograms are used, with the purpose of determining a pattern of the different autocorrelations. In the same way, the correlogram is used to evaluate if there is some kind of seasonal variation, not eliminated by seasonal differences.

b. Estimation of Parameters of the Model. For each tentative model the parameters must be estimated. This can be done using the ordinary least squares method, the Yule-Walker equation or the maximum likelihood method.

c. Checking the diagnosis. Classic statistics should be calculated to measure the fit of the data using error measures and / or information criteria (AIC or BIC), the statistical significance of the estimated coefficients, unit root tests on the residuals of the model, and also must verify that there is no autocorrelation.

**ARCH Model**

Starting from a first order autoregressive stationary model:

$$y_t = a_0 + a_1 y_{t-1} + \varepsilon_t \quad (2)$$


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When making a forecast, the conditional mean for the period $y_{t+1}$ is:

$$E_t y_{t+1} = a_0 + a_1 y_t \quad (3)$$

While the conditional variance:

$$var(y_{t+1}|y_t) = E_t[(y_{t+1} - a_0 - a_1 y_t)^2]) = E_t(\varepsilon_{t+1})^2 \quad (4)$$

Up to this point, it is established that $E_t(\varepsilon_{t+1})^2$ equals $\sigma^2$, but by assuming that the conditional variance is not constant, it must be modeled as an AR (q) process using the squares of the estimated errors, so that:

$$\hat{\varepsilon}_t^2 = \alpha_0 + \alpha_1 \hat{\varepsilon}_{t-1}^2 + \ldots + \alpha_q \hat{\varepsilon}_{t-q}^2 + v_t \quad (5)$$

Where v_t is a white noise process. If the values of$\alpha_1, \alpha_2, \ldots\ , \alpha_n$ are equal to zero, the estimated variance is only a constant $\alpha_0$. Otherwise, the conditional variance of y_t evolves according to an autoregressive model. Thus, the conditional variance in the period t+1 is denoted as:

$$E_t \hat{\varepsilon}_{t+1}^2 = \alpha_0 + \alpha_1 \hat{\varepsilon}_t^2 + \cdots + \alpha_q \hat{\varepsilon}_{t+1-q}^2 \quad (6)$$

For this reason, an equation like this one is called a model with conditional autoregressive heteroskedasticity (ARCH for its acronym in English). The residuals of said equation can come either from an autoregressive, an ARMA model or a standard regression model.

However, the specification of (5) is not the most convenient, since it is better to estimate simultaneously y_t and its conditional variance. Thus, Engle in 1982, showed that it was possible to simultaneously model the mean and the variance of a series. The proposed model is:

$$\varepsilon_t = v_t \sqrt{\alpha_0 + \alpha_1 \varepsilon_{t-1}^2} \quad (7)$$

Where $v_t$ is a white noise process in which $\sigma_v^2 = 1$, y $v_t$ y $\varepsilon_{t-1}$ They are independent of each other. In addition, the parameters from $\alpha_0$ and $\alpha_1$ must be constants such that $\alpha_0 > 0$ y $0 \leq \alpha_1 \leq 1$, being this last condition which ensures that the process is stable.

**GARCH Model**

In 1986, Bollerslev extends Engle's work by developing a technique that allows conditional variance to be an ARMA process. Being the error of said process:

$$\varepsilon_t = v_t \sqrt{h_t} \quad (8)$$

Where $\sigma_v^2 = 1$ and $h_t = E_{t-1}(\varepsilon_t)^2$. Being $v_t$ a white noise process, its conditional mean is equal to zero. For its part, the conditional variance is $E_{t-1}\varepsilon_t^2 = h_t$, where the conditional variance of ε_t is an ARMA process given by $h_t$. Thus, the GARCH model:

$$h_t = \alpha_0 + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 + \sum_{i=1}^{p} \beta_i h_{t-i} \quad (9)$$

Where:

- $\sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2$ they are the lags of error
- $\sum_{i=1}^{p} \beta_i h_{t-i}$ are the lags of the conditional variance.

So that:

- A GARCH model (1.0) has the form $h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2$, which is identified by the lags of the squared error $\varepsilon_{t-1}^2$ (Equivalent to an ARCH model (1))
- A GARCH model (0,1) has the form $h_t = \alpha_0 + \beta_1 h_{t-1}$, which is identified by the lags of the variance $h_{t-1}$


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Another way of representing the stochastic process of the exchange rate is through lag operators, so that:

$$h_t = \alpha_0 + A(L)\varepsilon_t^2 + B(L)h_t \qquad (10)$$

According to Bollerslev (1986), the GARCH process (p, q) as defined in (10) is stationary in the broad sense with $E_t(\varepsilon_t) = 0$, $\mathrm{Var}(\varepsilon_t) = \alpha_0(1 - A(1) - B(1))^{-1}$y $\mathrm{Cov}(\varepsilon_t, \varepsilon_s) = 0$ for t≠s only if $A(1) + B(1) < 1$. This condition of stationarity is important to ensure that the moments of the normal distribution are finite.

The benefit of a GARCH model is that ARCH models of higher order can have a more parsimonious GARCH representation, this makes it easier to identify and estimate, as well as implying less restrictions on the coefficients. Another key characteristic is that the conditional variance of the perturbations of the exchange rate sequence acts as an ARMA process.

Just as an ARMA process is identified with its simple Autocorrelation (FAC) and partial (FACP) functions of the perturbation term, the FACP of the quadratic residuals can help to identify the order of the GARCH process, for this a test of Lagrangian multiplier McLeod & Li (1983).

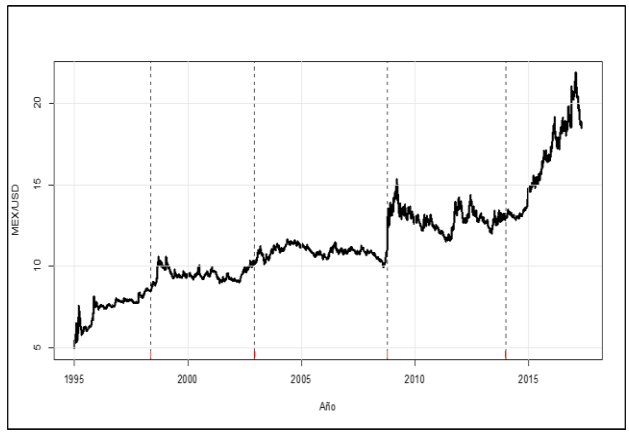
## 3. Econometric Methodology

### Description of the Data

To carry out the estimation of the model, the daily nominal exchange rate of the Mexican peso against the US dollar was considered, during the period from January 1, 1995 to April 26, 2017, with a total of 8,152 observations. The data was obtained from the International Monetary Fund, from its section International Financial Statistics (IFS for its acronym in English).

### Analysis of the exchange rate: Stationarity of the Series

The analysis of the time series begins with the preliminary verification of the stationary nature of the exchange rate. In the inspection of graph 3, it can be observed that the variable (peso / dollar exchange rate) is non-stationary in levels, due to its strong upward trend. In this way, in order to prove the stationarity in the logarithm of the exchange rate, the Dickey-Fuller Augmented Test (ADF) and the Phillips-Perron (PP) tests were used. See table 1.1.




**Grpah 3** Peso-dollar exchange rate (monthly). 1995-2017
*Source: Own elaboration with results of the software R 3.3.3*

| EN NIVELES | | | | | |
|---|---|---|---|---|---|
| Tipo de cambio pesos/dólar | DFA | | PP | | Orden de integración |
| | t-estadístico | Probabilidad | t-estadístico | Probabilidad | |
| Intercepto | -0.584131 | 0.8718 | -0.809078 | 0.8160 | I (1) |
| Tendencia e intercepto | -2.141430 | 0.5219 | -2.467433 | 0.3445 | I (1) |
| Sin tendencia ni intercepto | 1.950423 | 0.9883 | 1.850876 | 0.9851 | I (1) |
| **EN DIFERENCIAS** | | | | | |
| | DFA | | PP | | Orden de integración |
| | t-estadístico | Probabilidad | t-estadístico | Probabilidad | |
| Intercepto | -40.47903 | 0.0000 | -84.76458 | 0.0001 | I (0) |
| Tendencia e intercepto | -40.47842 | 0.0000 | -84.75945 | 0.0001 | I (0) |
| Sin tendencia ni intercepto | -40.41206 | 0.0000 | -84.71580 | 0.0001 | I (0) |

**Table 1** Unit root test
*Source: Own elaboration with software results from Eviews 9.0*

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The results obtained from the tests (ADF)[1] and (PP) in table 1.1, they show that when applying the algebraic transformation of the logarithm of the exchange rate (TC) pesos / dollar per month, in level, the variable showed that the critical values at a level of significance of 1% do not reject the null hypothesis that the logarithm of the variable in levels is non-stationary.

Therefore, to avoid the problem of spurious regression[2] that could arise when performing the regression of a non-stationary series of time, it is necessary to transform the series through logarithmic differences. In this sense, the unit root analysis confirmed the stationarity after taking the first differences of the logarithm of the TC peso / dollar. Defined as follows:

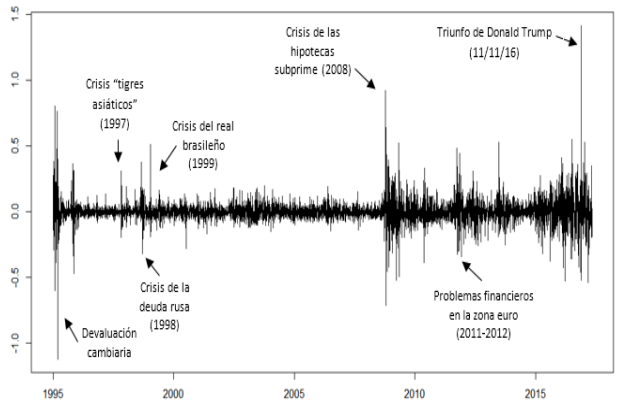
$$\Delta y_t = y_t - y_{t-1} = \log\left(\frac{TC}{TC_{t-1}}\right) = \log\left(1 + \frac{TC - TC_{t-1}}{TC_{t-1}}\right)$$

Where:
$y_t$ =log (TC)

However, despite the fact that the first differences in logarithms of the TC are stationary, Figure 4 suggests that during most of the period analyzed, the different economic and social events that have caused a rise or fall in the exchange rate volatility of the Mexican economy. Thus, for example, the devaluation of the Mexican peso in December 1994 is shown, which resulted in low levels of international reserves and a growing mobility in international capital flows. In this sense, there are other periods of volatility, in the years 1997, 1998 and 1999.

Which according to Caballero (2016) can be attributed to the crisis of the "Asian tigers", which occurred in mid-1997, the crisis of the Russian debt, in 1998, and the crisis of the Brazilian real, in 1999.

Also, it can be observed that the years 2005, 2006 and 2007 are periods of controlled volatility. On the other hand, the periods of high exchange volatility have their origin in the subprime mortgage crisis, which occurred in the United States in 2008 and reached its effects in 2009 and 2010, coupled with this, the exchange rate presented another period of volatility due to the worsening of the financial problems in the Euro Zone that generated pressures on the exchange rate at the end of 2011 and the beginning of 2012. Finally the historical fall of the peso before the triumph of Donald Trump in November 2016 again pressures on the exchange rate.




**Graph 4** Percentage change of peso-dollar exchange rate, 1995-2017
*Source: Own elaboration with software results from R 3.3.3*

[1] The Dickey-Fuller (DFA) augmented test is a DickeyFuller test version for much larger and more complicated time series models. The DFA is a negative number and the more negative the statistic (with respect to critical values) the stronger the rejection of the null hypothesis about the existence of a unitary root or nonstationarity. The null hypothesis is accepted because the value of DFA is lower in absolute value (less negative) than the critical value of McKinnon at 5% (Mata, 2003, p.30 y 32).

[2] The problem of spurious regression, is that generally the results tend to be admitted as good, although in reality they are only due to casual aspects.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**Modeling the stochastic process structure (ARIMA) (Box-Jenkins Methodology)).**

The objective of the Box-Jenkins methodology (also technically known as ARIMA methodology) is to identify and estimate a general class of models capable of forecasting real time series, through a statistical method that can be interpreted as a generator of information. the sample. This method consists of three stages:

1. Identification: For the choice of model, the command "auto.arima" of software R 3.3.3 was used. which automatically selects the order of the ARIMA process minimizing the Aikakie Criterion (AIC) and / or the Schwarz Bayesian Information Criterion (BIC)

2. Estimation: In this stage tentative models are adjusted and the parameters of each of the models identified in the previous phase are estimated (see table 1.2).

3. Diagnosis: This phase was carried out the tests of correct specification to ensure that the residues mimic the process of a white noise, that is, the residues of the optimal model were plotted, their simple and partial correlograms, the unit root tests were applied , and another proof of non-autocorrelation.

| | Modelo 1 ARMA (5,2) | Modelo 2 ARMA (2,2) | Modelo 3 ARMA (1,1) | Modelo 4 MA (3) | Modelo 5 MA (1) |
|---|---|---|---|---|---|
| *AR (1)* | *1.4836**** | *1.0655**** | - | - | - |
| | (128.3564) | (7.7498) | - | - | - |
| *AR (2)* | *-1.0290**** | *-0.4106**** | *-0.8552**** | - | - |
| | (-79.1647) | (-3.3250) | (-13.0466) | - | - |
| *AR (4)* | *0.0719**** | - | - | - | - |
| | (6.1795) | - | - | - | - |
| *AR (5)* | *-0.0906**** | - | - | - | - |
| | (-9.2039) | - | - | - | - |
| *MA (1)* | *-1.4718**** | *-1.0503**** | - | *0.0195** | - |
| | (-216.4884) | (-7.4505) | - | (1.7664) | - |
| *MA (2)* | 0.9691*** | 0.3495*** | 0.8298*** | -0.0436*** | -0.0401*** |
| | (145.1894) | (2.6960) | (11.7548) | (-3.9602) | (-3.6226) |
| *MA (3)* | - | - | - | *-0.0845**** | - |
| | - | - | - | (-7.6545) | - |
| Constante | *0.0161*** | *0.0161*** | *0.0163*** | *0.0162*** | *0.0016*** |
| | (2.4349) | (2.4697) | (2.1825) | (2.4097) | (2.2389) |
| Observaciones | 8151 | 8151 | 8151 | 8151 | 8151 |
| $R^2$ | *0.0176* | *0.0070* | *0.0023* | *0.0086* | *0.0016* |

*t-estadístico entre paréntesis
Nivel de significancia ***p < 0.001, ** p < 0.05, * p < 0.1

**Tabla 2** Estimación de los modelos ARIMA: Metodología Box-Jenkins[3]
*Source: Own elaboration with software results from E-views 9.0*

**Modeling the volatility of the exchange rate in Mexico**

To identify the possible volatility existing in the time series of the Exchange Rate, a regression is made of the logarithmic difference of the variable over a constant and its perturbations are obtained from this equation. From the data, the following regression was obtained by MCO:

$$Y_t = \beta_1 + u_t \quad (11)$$

Where $Y_t$ = percentage change in the exchange rate and $u_t$ = random error term

$\widehat{Y}_t = 0.016300$
t = 2.147921

[3] * The scripts represent models that did not turn out to be statistically significant


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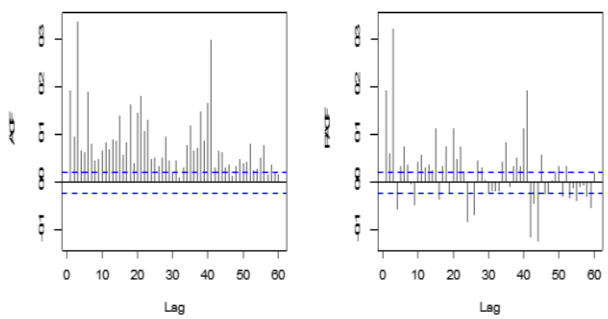
From the previous regression the residuals were obtained ($\varepsilon_t$) and were squared ($\varepsilon_t^2$) to use them as a measure of volatility. Being a quadratic value, it will be high in periods in which large changes in prices are experienced and small when there are moderate changes in the prices of said goods.




**Graph 5** Correlogram of the Quadratic Residues
*Source: Own elaboration with software results from R 3.3.3*

To formally verify that there is an ARCH or GARCH effect in the TC, the test proposed by Mc Leod and Li (1983) is used, its methodology involves two steps:

Step 1. The Ordinary Least Squares (OLS) method is used to estimate the most appropriate regression equation, and denote the residuals.

Step 2: Delay the square debris on a constant and on the delay of the valuess "q" $\varepsilon_{t-1}^2$, $\varepsilon_{t-2,}^2$ $\varepsilon_{t-3}^2$, $\varepsilon_{t-q}^2$, , that is, an estimation of the form is made:

$$\varepsilon_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \cdots + \alpha_q \varepsilon_{t-q}^2 \qquad (12)$$

If there are no ARCH or GARCH effects, the estimated values of $\alpha_1$ a $\alpha_q$ must be zero. Therefore, this regression will have a little explanatory effect so that the coefficient of determination (ie, $R^2$ usual) It will be quite low.

Using a sample of residue T, under the null hypothesis of absence of ARCH errors, the test statistic $TR^2$ converges to a distribution $\chi^2$ with q degrees of freedom.

If $TR^2$ is large enough, the rejection of the null hypothesis that $\alpha_1$ a $\alpha_q$ are jointly equal to zero is equivalent to accepting the alternative hypothesis that there is an ARCH effect. On the other hand, if $TR^2$ is low enough, it is possible to conclude that there are no ARCH effects.

$$\varepsilon_t^2 = 0.2407 + 0.1779\,\varepsilon_{t-1}^2 + 0.3299\,\varepsilon_{t-3}^2 - 0.0625\,\varepsilon_{t-4}^2 + 0.0318\,\varepsilon_{t-5}^2 \qquad (13)$$

Their respective "t statistic" values are (5.24, 16.31, 31.60, -5.59 and 3.05). The nature of the model indicates that its quadratic disturbances manifest a considerable influence on the peso / dollar exchange rate. This indicates that if the volatility was high in the previous period, it will remain high in the current period, which indicates an accumulation of volatility. The sample value of the F statistic for the null hypothesis that the coefficients α1, α3, α4 and α5 are equal to zero is 342.86. And since lags 1, 3, 4 and 5 are significant (all coefficients have a statistical t greater than 2), the null hypothesis is rejected that there is no ARCH error at any level of significance and the existence of an ARCH or GARCH effect to explain the volatility in the TC.

Although the estimation of an ARCH or GARCH model allows to model the volatility of the TC, it is necessary to take into account the role of the structural change in the variable, since it can alter the variance and increase the volatility of the TC. Table 1.3 and Figure 1.1 show the dates of the four break points detected in the TC for the period analyzed.[4].

[4] The procedure used to determine the breakpoints in the series was developed using the "breakpoints" command in the "strucchange" library developed by Zeileis (2015).

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| | |
|---|---|
| First break point | 06/05/1998 |
| Second break point | 05/12/2002 |
| Third break point | 08/10/2008 |
| Fourth break point | 21/12/2013 |

**Table 1.3** Breakpoints in the exchange rate (1993-2017)
*Source: Own elaboration with information obtained from the software R 3.3.3*

With these results, a dummy variable is constructed to correct the effect of the structural changes on the TC and verify if this change has had significant effects on the parameters in the period analyzed. This fact is shown in equation 14, where the dummy variable that reflects the structural changes was statistically significant at a confidence level of 5%. In this sense, with the introduction of a dichotomous variable changes were detected by assigning the value 0 before and after the structural change, and 1 when exactly a breakpoint occurs in the variance of the series.

$$\varepsilon_t^2 = 0.6156 + 0.1772\ \varepsilon_{t-1}^2 + 0.3292\ \varepsilon_{t-3}^2 - 0.0629\ \varepsilon_{t-4}^2 + 0.0311\ \varepsilon_{t-5}^2 - 0.0328 \text{ dummy} \quad (14)$$

Their respective statistical values are: 3.37, 16.24, 31.52, -5.63, 2.98 and -2.12, respectively. Once the structural breaks in the variance are considered and by accepting the existence of an ARCH or GARCH effect to explain the volatility in the TC, the empirical strategy consists of estimating different models to measure the adjustment of the same: the alternatives include models that follow an autoregressive process of order ρ = 1,2 being the order of the process of moving averages; k = 1,2, and the ARCH terms in the variance modeling (see table 1.5).

For the selection of the best model, two traditional information criteria are used: the Akaike information criterion (1976), and the Bayesian information criterion of Schwarz (1978)[5]. The estimate was made jointly for the equations of mean and variance, in such a way that the order of the autoregressive processes in each responds to global selection criteria. The results are presented in table 1.4.

| | Modelo 1 ARMA (1,2) | Modelo 2 ARMA (2,2) | Modelo 3 MA (2) | Modelo 4 MA (1) | Modelo 5 MA (2) |
|---|---|---|---|---|---|
| *AR (1)* | ***0.7150*** | - | - | - | - |
| | (24.4723) | - | - | - | - |
| *AR (2)* | - | ***-0.2397*** | - | - | - |
| | - | (-2.3359) | - | - | - |
| *MA (1)* | ***-0.6738*** | ***0.0467*** | ***0.0562*** | ***0.0585*** | - |
| | (-22.1051) | (5.0925) | (5.0713) | (5.3031) | - |
| *MA (2)* | ***-0.0763*** | ***0.1971*** | ***-0.0304*** | - | ***-0.0314*** |
| | (-9.6190) | (1.8694) | (-2.5575) | - | (-2.6326) |
| | | Ecuación de la Varianza | | | |
| *Constante* | ***0.2004*** | ***0.2006*** | ***0.0035*** | ***0.0035*** | ***0.0035*** |
| | (45.3405) | (52.5983) | (19.9510) | (19.8513) | (20.3808) |
| $\varepsilon_t^2$ | ***0.0451*** | ***0.0454*** | ***0.0838*** | ***0.0840*** | ***0.0843*** |
| | (28.6046) | (28.5800) | (46.5701) | (46.6093) | (46.4599) |
| *GARCH (1)* | ***0.4951*** | ***0.4954*** | ***0.9089*** | ***0.9086*** | ***0.9084*** |
| | (49.6912) | (57.1514) | (537.8678) | (534.3986) | (539.2924) |
| Observaciones | 8150 | 8149 | 8151 | 8151 | 8151 |
| $R^2$ | 0.0094 | 0.0025 | -0.0002 | -0.0012 | 0.0009 |
| Criterio Akaike | 1.7921 | 1.7920 | 1.3352 | 1.3357 | 1.3375 |
| Criterio Schwarz | 1.7973 | 1.7972 | 1.3391 | 1.3392 | 1.3410 |

**Table 1.4** Estimated models for exchange volatility
*Source: Own elaboration with information obtained from the software E-views 9.0*

Following these information criteria, the results indicate that of the five proposed models, the model that best adjusted to the monthly information was Model 3 - which follows a process of moving averages of order two MA (2) -, since this presented the smallest values of the statistical criteria. Furthermore, it turned out to be consistent with the structural changes, since the dummy variable that represents the breakpoints is statistically significant (table 1.5).

[5] $AIC = T * \log(SRC) + 2 * n$
$BIC = T * \log(SRC) + n * \log(T)$

Where n = number of estimated parameters (p + q + constant term) and T = number of observations used.

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| Variable | Coefficient | Standard Error | Z-Stadistica | Probability |
|---|---|---|---|---|
| MA (1) | 0.0569 | 0.0111 | 5.112 | 0.0000 |
| MA (2) | -0.0309 | 0.0119 | -2.5946 | 0.0095 |
| Equation of Variance | | | | |
| C | 0.0036 | 0.0001 | 19.8387 | 0.0000 |
| RESID(-1)^2 | 0.0825 | 0.0017 | 45.9527 | 0.0000 |
| GARCH(-1) | 0.9091 | 0.0016 | 536.0606 | 0.0000 |
| DUMMY | 0.2722 | 0.0335 | 8.1250 | 0.0000 |

**Table 1.5** Estimation of the ARIMA-GARCH Model
*Own:Elaboration with the software Eviews 9.0*

It is convenient to point out that in particular the use of the GARCH model (1,1) has specific advantages to forecast the exchange volatility, among the main ones it has that: i) it allows more parsimonious specifications than the ARCH model, avoiding the over parameterization of the specification and, thereby, facilitating the maintenance of the model; ii) among the ARCH / GARCH family models is the most common specification, which is why its properties are already known; and iii) it fits very well the data of financial variables, mainly when the observations are of high frequency (Ortiz, et. al, 2012).

## Results

Financial time series, such as the exchange rate, often present the phenomenon of volatility accumulation, that is, there are periods in which their prices show high variations and others in which they present relative stability. In this sense, several models have been developed in the empirical literature to estimate the volatility of financial variables.

The models most commonly applied to estimate the volatility of the exchange rate are the autoregressive models with conditional heteroscedasticity (type ARCH and GARCH). In this regard, the objective was to analyze and explore through the ARCH and / or GARCH models the evolution of volatility in the exchange rate in Mexico.

In the previous section, the estimation of the volatility of the exchange rate in Mexico for 1995-2017 is developed using these models of conditional heteroscedasticity. From the above results, expressed in equation (13), the existence of ARCH and GARCH effects can be clearly observed. It is found that the volatility of the exchange rate in Mexico is an example of an ARIMA (0,0,2) + GARCH (1,1) model in which it is proven that the conditional volatility in the exchange rate in Mexico has been highly persistent As such, for the Mexican economy it must be anticipated that any shock that generates uncertainty in the foreign exchange market will tend to show little tendency to dissipate..

## Conclusions

It is important to monitor the dynamics of the exchange rate, whether in developed or developing countries, since it is an important transmission channel of monetary policy. Their behavior not only has an impact on the price level, but also on the productivity and performance of financial instruments. This is why it becomes necessary to have models that explain not only the reactions to yields and risks, but also regarding volatility.

In the case of Mexico, the management of the exchange rate has been of vital importance, which despite being classified as a free floating regime, has been characterized by constant interventions by the monetary authorities in the exchange market to maintain a certain value of the currency, thus avoiding strong depreciation, becoming the main tool to achieve the objective of stability of inflation. In this way, the analysis and results achieved in this document show that, the exchange rate presents volatility, when presenting conditional heteroscedasticity in its residuals, which was verified through the ARCH and GARCH models. However, knowing the existence or not of volatility becomes insufficient if the factors that have triggered it are not known.

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In the case of Mexico, this has been generated not only by internal shocks, but also by international events, and in the last decade, those originating from the environment of the US economy (subprime crisis and election of Donald Trump) have been those of greater importance, due to the high economic dependence that this country has.

Added to this, this volatility has a persistent effect, so that oscillations in previous periods show a high degree of persistence. Knowing this behavior is important to make correct predictions about future values, ignoring volatility, can lead to errors in the estimates, which could have a negative effect on investors and risk managers.

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# Prognosis of the monetary base of Mexico. Algorithm for the box-jenkins methodology (1985-2015)

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## Abstract

The present research aims to provide a relevant algorithm for the proper identification of a data generating process (economic and financial variables) by using the "auto.arima" command, belonging to the forecast library (R statistical software), to identify the optimal parameters of the ARIMA model. Considering the methodological framework of Box and Jenkins process (1970), it seeks to achieve, by solving a stochastic difference equation, the correct calibration and obtaining an optimal forecast for the Mexican Monetary Base, one of the main economic variabes.

**Forecast, Monetary Base, ARIMA Models**

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## I. Introduction

The main motivation of this research work lies in the need for researchers and professionals in the economic and financial area to have an algorithm that is capable of developing adequate and reliable forecasts on univariate time series. In practice it is very common to have a sample of a few dozen observations that need to be predicted, even when the projection of a small number of periods is required, an algorithm that allows the calibration of an optimal forecast could be adequate, through a well defined sequence, based on the Box-Jenkins methodology and that also solves its main difficulty, that is, the correct identification of the scheme that represents the time series. Identifying not only the possible stochastic autoregressive processes and moving averages, but their possible ordinary and seasonal differences. Under these circumstances, an algorithm for forecasting becomes an essential tool.

In recent years, different statistical softwares have been developed and perfected that seek to automate, and in this way facilitate procedures for the construction of forecasts. The use of computers, information technologies, and the large amounts of data available have led institutions and organizations to use these elements together to improve research and decision making. Mathematical models (differential and difference equations) that represent in a simplified way the behavior of the event (variable) that is analyzed have also been required.

With the above elements and the proliferation of free software R, it is sought to amalgamate all the elements involved in the modeling of a data generating process to achieve its correct analysis, identification, estimation and projection. The research work is divided into six sections.

After this introduction, in the second section a review of the literature referring to the advances in the development of algorithms capable of carrying out automated forecasting is carried out; in the third, the theory referring to the ARIMA models, the concept of stationarity and the ways of checking it are addressed; in the fourth, the stages that make up the Box-Jenkin methodology are explained in detail; later, in the fifth section an empirical application is made for the time series of the Monetary Base of Mexico; in the penultimate section the results obtained from the forecast are presented and finally the conclusions are presented.

## 2. Review of Literature

A very common obstacle when using ARIMA models for forecasting is that the process in order selection is considered subjective and difficult to apply. In the last three decades several attempts have been made to automate the modeling of ARIMA processes.

Hannan and Rissanen (1982) proposed a method to identify the order of an ARIMA model for a series of stationary time. In his method, innovations can be obtained by adjusting a long autoregressive model for the data, and later the likelihood of the potential models is calculated through a series of standard regressions. They establish the asymptotic properties of the procedure under very general conditions.

Liu (1989) proposed a method for the identification of seasonal ARIMA models using a filtering method and certain heuristic rules; This algorithm is used in the SCA-Expert software. Gershenfeld and Weigand (1993) indicate that the selection of ARMA models is not simple. The ARMA models in general can, after choosing the autoregressive order and moving averages, adjust by means of least squares regression to find the values of the parameters that minimize the error term.

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It is generally considered good practice to find the smallest values of the processes that provide an acceptable fit to the data. Brockwell and Davis (2009) recommend using the Akaike Information Criterion (AIC) to find the appropriate number of lags for each process.

Gómez (1998) extended the identification method of Hannan-Rissanen to include the multiplicative seasonality to the identification of the ARIMA model. Gómez and Maravall (1998) implemented this automatic identification process in the SEATS software. For a given time series, the algorithm tried to find the model with the lowest Bayesian Information Criterion (BIC). Other approaches are described by Mélard and Pasteels (2000) whose algorithm for ARIMA Univariate models also allow an intervention analysis. This is implemented in the Time Series Expert software (TSE-AX).

There are some algorithms in commercial software, although these are not documented in public domain literature. They emphasize, Forecast Pro (Goodrich, 2000) that is well known for its excellent automatic algorithms for ARIMA models that were used in the M3-forecasting competition (Makridakis and Hibon, 2000). Another algorithm for commercial use is implemented in Autobox (Reilly 2000). For their part, Ord and Lowe (1996) provide a review of some commercial software that implements automatic ARIMA forecasts. Among the most used in the economic and actuarial area are: EViews, GAUSS, Gretl, Mathematica, Matlab, Minitab, SAS, Shazam, Stata, Statgraphics, SPSS.

In recent years, the R statistical software has been developing, through the paradigm of object-oriented programming, a language and environment for computational statistics and graphics, similar to the S language originally developed by Bell laboratories.

It is an open source solution for data analysis that is supported by a large and active community of researchers around the world (Kabacoff, 2011: 5). R has the following characteristics to recommend it:

- Most commercial statistical software platforms cost thousands, if not tens of thousands of pesos. R is free! If you are a teacher or student, the benefits are obvious.
- R is a comprehensive statistical platform, offering all kinds of data analysis techniques. Almost any type of data analysis can be done in R.
- R has state-of-the-art graphic capabilities. R has the most complete and powerful feature set available.
- R can easily import data from a wide variety of sources, including text files, database management systems, statistical packages and specialized data repositories.
- R provides an unprecedented platform for the programming of new statistical methods in an easy and direct way
- R contains advanced statistical routines that are not yet available in other packages. In fact, new methods are available for download on a weekly basis.

Some of the most interesting features of R are available as optional modules that can be downloaded and installed. There are more than 10,000 user-contributed modules called libraries, which provide a wide range of new algorithms. Libraries are collections of functions in R, and compiled code in a well-defined format.

Rob Hyndman (2008) has developed the "forecast" library, which is a collection of functions to develop methods and tools to display and analyze forecasts of time series that include ARIMA modeling automatically.


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It is available for the R system of statistical computing (R Development Core Team 2008) is available in the network of integral files of the R project at: https://cran.rproject.org/web/packages/forecast/forecast.pdf. With the development of these and other functions it is possible to implement an algorithm capable of identifying the data generation process (PGD), to later estimate the coefficients of the integrated autoregressive processes of moving averages, which subsequently must be diagnosed to show their goodness of adjustment, and if the model is adequate considering these hypothesis tests, the last step may be the realization of a forecast.

## 3. Theoretical framework of time series prognostics

The theory of difference equations underlies all time series methods. In turn, time series econometrics is responsible for the estimation of equations in differences that contain a stochastic component. The proper estimation of an equation can be used for the interpretation of economic-financial data and for hypothesis testing.

The task faced by time series macroeconometricians is to develop reasonable and parsimonious models capable of forecasting, interpreting, and empirically testing hypotheses related to the stylized facts of the economic variables. This is how a methodology was developed to decompose a series into four components: trend, seasonality, cycle and an irregular component. The trend component represents the long-term behavior of the series and can be increasing or decreasing, the seasonal variation is an observed behavior with frequency less than or equal to the year, and just as the trend can be eliminated or modeled, in turn, the cyclical component represents regular periodic movements with length greater than one year, and the irregular component is a stochastic process (González, 2011: 17).

The objective of time series econometrics is to estimate and forecast these components. A time series is a sequence of data points recorded over time. For example, share prices, exports and imports, the monetary base, interest rates, the exchange rate, prices, the employment rate, international reserves, or industrial production, among others. If the data are unique numbers, the term univariate time series is used; For the vectors that consist of several series of numbers, the term multivariate time series is used.

Time series are considered to be realizations of an unknown stochastic process called the data generation process (PGD). The objective of the time series analysis is to model this process. By doing this, a formula is derived that describes the time series and can also be used frequently for forecasts (Pfaff, 2015: 20)

The methodology generally used to develop such forecasts requires finding the trajectory of the equation that directs the stochastic process and using it to predict the subsequent data. An equation in differences expresses the value of the variable as a function of its own lagged values, time and other variables. (Enders, 2015: 3). The representation of a linear difference equation of higher order with a constant coefficient is given by:

The equation is linear because all the values of the dependent variable are elevated to the first power. The term x_t is called forced process. The form of this can be very general; x_t can be some function of time, current or lagged values of other variables and / or stochastic processes. From an adequate choice of the forced process, we can obtain a wide variety of important macroeconomic models. In the econometric analysis, the forced process will contain both deterministic and stochastic components.


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The most representative cases being the following: the constant case x_t = 0, in this case we speak of an equation in differences in its traditional form; the exponential case $x_t = b(d)^{rt}$; and the deterministic trend case $x_t = b(t)^d$ and the stochastic case$x_t = \sum_{i=0}^{\infty} B_i E_{t-i}$.

**ARIMA models**

The time series were mainly studied under a deterministic aspect, at least until 1927, when Yule introduced the notion of the stochastic component. According to the author, each approximation to the time series can be considered as the performance of a stochastic process. This idea launched a different number of time series methods, varying in the estimation of parameters, identification, forecast and verification method.

Box and Jenkins integrated the existing knowledge and made an advance in the area creating a coherent and versatile approach that identified the three-stage iterative cycle for the time series: identification, estimation and verification of the diagnosis. The evolution of computers returned to the integrated autoregressive models of moving average (ARIMA) more popular and applicable in many scientific fields.

It is possible to combine a process of moving averages with a linear difference equation to obtain an autoregressive model and moving averages (ARMA). Consider the equation in differences of order "p". And since the forced process $\{X_t\}$ can be an MA (q) process given by: (2)

**In this way:**)

Following the convention of normalizing the units, this implies that $B_0$ is always equal to the unit. If the characteristic roots of equation (3) are all within the unit circle, $\{Y_t\}$ is known as the ARMA model for $Y_t$. The autoregressive part of the model is the differential equation given by the homogeneous portion of (2) and the part of the moving average is the sequence $\{X_t\}$. If the homogeneous part of the equation in differences contains "p" lags and the model for $X_t$ contains q lags, the model is called ARMA (p, q). If q = 0. The process is called pure autoregressive, denoted by AR (p), and if p = 0, the process is a pure moving average, denoted by MA (q).

In an ARMA model it is perfectly permissible that p and / or q are infinite. If one or more of the characteristic roots of (3) is greater than or equal to the unit, the sequence $\{Y_t\}$ is said to be an integrated process and in this case the model is called Integrated Self-Regressive Moving Averages (ARIMA) (Enders). , 2015: 50).

If we treat equation (3) as a difference equation, it can be solved for Y_t in terms of the sequence $\{E_t\}$. For the general model ARMA (p, q) of equation (3) when using the lag operator we have to: The sum will lead to an MA (∞) process. The important thing is to determine if such expansion is convergent with what the stochastic difference equation given in (5) is stable[6].

**Stationery**

In formal terms, the stationarity of a time series is defined in two ways. The first concept of stationarity is in a strong or strict sense.

[6] The stability condition is that the roots of the polynomial $\left(1 - \sum_{i=1}^{p} a_i L^i\right)$ they must fall outside the unit circle. This would also show that $Y_t$ is a linear stochastic difference equation, so the stability condition is necessary for the time series $\{Y_t\}$ be stationary.


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It is said that a time series $Y_t$ is stationary in a strict or strong sense, if its function of joint probability distribution remains identical in time. That is, it is stationary in the strict sense, if and only if:

$$f(Y_t, Y_{t-1}, \dots, Y_{t-k}) = f(Y_{t+T}, Y_{t-1+T}, \dots, Y_{t-k+T}), \ \forall T \in \mathbb{R} \qquad (1)$$

While stationarity in a weak or broad sense. It is said that a series of time is stationary in a broad or weak sense, if and only if it satisfies three conditions:

1. Your average is constant in time. $E(Y_t) = E(Y_{t+T}) = \mu \ \forall T \in \mathbb{R}$. If there is no trend, it can be assumed that the mean is constant and that the observed value for each period can be represented by a constant that will be the sample mean.
2. The variance is constant over time. The dispersion of the process is also invariant in time. $Var(Y_t) = Var(Y_{t+T}) = \gamma \ \forall T \in \mathbb{R}$.
3. The autocorrelation function is independent of time. This measures the possible dependence between an observed value ($Y_t$) and another ($Y_{t-k}$) that is separated by a range of length k.

If the time series is stationary, then the values of the mean, variance and autocorrelation function can be estimated by considering the time series as a sample of defined size, whose parameters are constant over time. Otherwise, when the time series is non-stationary, the problem is that the different samples represent samples of size one, which is not representative, so it is practically impossible to infer the properties of the population from these data (González, 2011: 53).

**Stationarity tests**

There are several tests to identify if a certain time series is stationary, among the most used in a prominent way in the literature are: 1) Graphic analysis; 2) The correlogram test, and its corresponding simple autocorrelation function (FAC) and partial autocorrelation function (FACP); and 3) The unit root test. The last two are explained as the fundamental basis of the analysis of ARIMA models.

**Simple and Partial Autocorrelation Function**

Autocovariances of each time point divided by the initial autocovariance ($p_s = \frac{\gamma_s}{\gamma_0}$) produces the autocorrelations (table 1), which in turn serve as a mathematical and visual representation (correlogram) in the Box-Jenkins methodology to identify and estimate the time series models. The autocorrelation function (FAC) should depend only on the "s" interval between two variables and not on its position at time t. For its part, the Partial Autocorrelation function (FACP) measures the marginal contribution or the weight of each new autoregressive variable that is added to the model. Table 1 shows some of the most representative stochastic processes.

| Model | Representation | Equation |
|---|---|---|
| White noise | ARIMA(0,0,0) | $\Delta Y_t = E_t$ |
| Random Walk without Drift | ARIMA(0,1,0) | $Y_t = Y_{t-1} + E_t$ |
| Random Walk with Drift | ARIMA(0,1,0) | $Y_t = a_0 + Y_{t-1} + E_t$ |
| Autoregressive | ARIMA(p,0,0) | $Y_t = a_0 + a_1 Y_{t-1} + \cdots + a_p Y_{t-p} + E_t$ |
| SMA | ARIMA(0,0,q) | $Y_t = a_0 + E_t + B_1 E_{t-1} + \cdots + B_q E_{t-q}$ |
| Autoregressive Integrated Mobile Media | ARIMA(1,1,1) | $\Delta Y_t = a_0 + a_1 \Delta Y_{t-1} + E_t + B_1 \Delta E_{t-1}$ |

**Table 1** Representation of various Stochastic Processes
*Source: self made*

For each of the different stochastic processes, the corresponding mean, variance and autocovariance must be obtained, since this will allow determining if the determined stochastic process is stationary or not.


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By dividing the autocovariance between the variance, the corresponding simple autocorrelation function is obtained, which is independent of time. Below is a Table (2) summary of the first two statistical moments and the autocovariance of the most common stochastic processes.

| Proceso | Media | Varianza | Autocovarianza |
|---|---|---|---|
| AR(1) | $\frac{a_0}{1-a_1} = u$ | $\frac{\sigma^2}{1-a_1^2} = \gamma_0$ | $\frac{\sigma^2(a_1)^3}{1-a_1^2} = \gamma_s$ |
| AR(2) | $\frac{a_0}{1-a_1-a_2} = u$ | $\frac{(1-a_2)\sigma^2}{(1+a_2)(1-a_1-a_2)(1+a_1-a_2)} = \gamma_0$ | $a_1\gamma_{s-1} + a_2\gamma_{s-2} = \gamma_s$ |
| AR(p) | $\frac{a_0}{1-a_1-a_2-\cdots-a_p} = u$ | $a_1\gamma_1 + a_2\gamma_2 + \cdots + a_p\gamma_p + \sigma^2 = \gamma_0$ | $a_1\gamma_{s-1} + a_2\gamma_{s-2} + \cdots + a_p\gamma_{s-p}$ |
| MA(1) | $a_0 = u$ | $(1+B_1^2)\sigma^2 = \gamma_0$ | $\gamma_1 = B_1\sigma^2, \quad y\ \gamma_s = 0, \forall$ |
| MA(2) | $a_0 = u$ | $(1+B_1^2+B_2^2)\sigma^2 = \gamma_0$ | $\gamma_1 = (B_1+B_1B_2)\sigma^2;$ $\gamma_2 = (B_2)\sigma^2;$ $\gamma_s = 0, \forall\ s > 2$ |
| MA(q) | $a_0 = u$ | $(1+B_1^2+B_2^2+\cdots+B_q^2)\sigma^2 = \gamma_0$ | $B_s\sigma^2 = \gamma_s$ |
| ARMA(1,1) | $a_0 = u$ | $\frac{(1+B_1^2+2a_1B_1)\sigma^2}{1-a_1^2} = \gamma_0$ | $\frac{(1+a_1B_1)(a_1+B_1)\sigma^2}{1-a_1^2}$ |

**Table 2** Mean, variance and autocovariance of different processes
*Source: self made*

For example, in an AR (1) process, $Y_t$ and $Y_{t-2}$ are correlated even when $Y_{t-2}$ does not appear directly in the model. The correlation between $Y_t$ and $Y_{t-2}$, ie $p_2$, is equal to the correlation between $Y_t$ and $Y_{t-1}$, ie p_1 multiplied by the correlation between $Y_{t-1}$ and $Y_{t-2}$, $p_1$ again, so $p_2 = (p_1)^2$. It is important to note that such indirect correlations are present in the Simple Autocorrelation function of any autoregressive process.

On the other hand, the partial correlation between $Y_t$ and $Y_{t-S}$ eliminates the effect of the values that intervenes from $Y_{t-1}$ up to and $Y_{t-S+1}$. In such a way that, in an AR (1) process, the Partial Autocorrelation between $Y_t$ and $Y_{t-2}$ equals zero.

**Raíz Unitaria (Prueba Dickey Fuller Aumentada)**

Assuming an ARIMA autoregressive model (1,0,0) whose algebraic representation is: $Y_t = a_1Y_{t-1} + e_t$, subtracting $Y_{t-1}$ from each side of the equation to write the process in an equivalent way like: $\Delta Y_t = \delta Y_{t-1} + e_t$, where $\delta = a_1 - 1$. Test the hypothesis that $a_1 = 1$, is equivalent to testing the hypothesis that $\delta = 0$. Dickey and Fuller (1979), considered three different regression equations that can be used to prove the presence of unit root.

The difference between the three regressions has to do with the presence of the deterministic elements a_0 and a_2 t. The first is a pure random walk model, the second includes an intercept or a drift term, and the third includes both a drift and a linear temporal trend. The parameter of interest in all the regression equations is $\delta$; if $\delta = 0$, sequence $\{Y_t\}$ contains a unit root The test involves estimating one or more of the equations described above using ordinary least squares (OLS) to obtain the estimated values of $\delta$ and its associated standard error. The result obtained is a distribution function called "tau" that allows determining if the null hypothesis should be rejected or not.

Dickey and Fuller (1981), developed a test in which the error term was correlated, and was called Dickey Fuller Augmented Test (DFA). This test involves increasing the three previous equations with the lagged values of the dependent variable $\Delta Y_t$ in such a way that the processes are determined as follows, Dickey and Fuller (1981), developed a test in which the error term was correlated, and was called Dickey Fuller Augmented Test (DFA). This test involves increasing the three previous equations with the lagged values of the dependent variable in such a way that the processes are determined as follows:


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The process $e_t$ It is a white noise. The term of lagged differences that must be included is identified by information criteria of Akaike and Schwarz. In these new regression models, the idea remains the same, that is, to prove that $\delta = 0$, based on the same tau distribution [7].

## 4. Methodology Box-Jenkins. Prognostics

The Box-Jenkins methodology for modeling the processes (Integrated Self-Regressive of Moving Averages) ARIMA was described in a highly influential book by statisticians George Box and Gwilym Jenkins in 1970. An ARIMA process is a mathematical model used to forecast. The Box-Jenkins methodology involves identifying an appropriate ARIMA process, adapting it to the data and then using the adjusted model for prediction. One of the attractive features of the Box-Jenkins approach to prediction is that ARIMA processes are a very rich class of possible models and it is usually plausible to find a process that provides an adequate description of the data (Hyndman, 2008).

The original Box-Jenkins methodology involves an iterative process of stages corresponding to the selection of models, parameter estimation and verification of the same. Recent explanations of the process often add a preliminary stage of data preparation and a final stage of application of the model (or forecast) (Makridakis, Wheelwright and Hyndman, 1998). The Box-Jenkins approach to construct linear models of time series is based on two main principles: The first, the principle of parsimony, which consists of always choosing the simplest model that is sufficiently representative of the data; and the second, the principle of iterative improvement, which consists of starting from a simple and feasible model, to which successive improvements will be made, until arriving at a satisfactory model.

The Box-Jenkins methodology consists of the following stages:

### Analysis of Stationarity and Seasonality

In the first stage it must be verified that the series is stationary and try to eliminate the seasonal variation, if it is the case. González (2011: 85) suggests the following order to deal with non-stationary models:

a. Stabilization of variance. To make the data homoscedastic, mathematical transformations are suggested such as: The square root, the neperian logarithm, the reciprocal or inverse, the reciprocal of the square root and the reciprocal of the logarithm. Another common transformation in economic series is to deflate the data.

b. Elimination of the trend. We proceed to review if the data present some kind of trend. If it exists, it will be eliminated through ordinary differences.

c. Treatment of seasonal variation. In some data it happens that the seasonal variation is visible from the graph of the original data or by stabilizing the variance. In other data it is possible to be warned until after the trend has been eliminated. If the seasonal variation is detected, it must be eliminated with seasonal differences or it must be represented by multiplicative models that include the seasonal component SARIMA (p, d, q) x $(P, D, Q)_m$, with "M" denoting seasonality.

[7] The levels of significance without constant at 1%, 5% and 10% are: -2.58, -1.95 and -1.62, respectively; with constant: -3.43, -2.86 and -2.57, while with constant and trend: -3.96, -3.41 and -3.12.


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d. Where m is the number of periods per station, capitalization notation is used to denote the seasonal part of the model and lowercase notation for the non-seasonal part of the model. The seasonal part of the model consists of terms that are very similar to the non-seasonal component, but these imply seasonal lags of the period. For example, a model SARIMA (1,1,1) x $(1,1,1)_{12}$, without constant for monthly data can be written as follows:

**Identification of the Tentative Model**

The correlograms are used for the graphical and statistical representation of the FAC and FACP, with the purpose of determining a pattern of the different autocorrelations[8], It will also be verified by hypothesis tests such as the Q statistic developed by Box and Pierce (1970) or the Ljung-Box statistic (1978). In the same way, the correlogram is used to evaluate if there is some kind of seasonal variation, not eliminated by seasonal differences.

**Estimation of Model Parameters**

For each tentative model the parameters must be estimated. This can be done using the ordinary least squares method, the Yule-Walker equation or the maximum likelihood method. The estimated values must be examined for significance and stability. If the model is not stable (implying an explosive trajectory) or the coefficients do not differ significantly from zero, the model should be re-examined and a new estimation of it should be proposed.

**Verification of the Model**

It is recommended to carry out the following analysis:

a. Classic statistics must be calculated to measure the fit of the data, this allows to compare the different models, both in their adjustment and in their forecasting capacity. Also known as error measures[9].

b. Perform the individual hypothesis tests (t-statistics) on the statistical significance of the estimated coefficients.

c. Carry out the tests on the residuals of the model, and obtain their simple and partial correlograms, to identify that they are stationary. Additionally, perform an Augmented Dickey-Fuller test (1979) to determine the stationarity of the disturbances.

d. Prove that there is no autocorrelation, for this purpose the test called "portmanteau" by Box-Pierce, and / or Ljung-Box is used.

**Forecast**

The most important use of an ARIMA model is to predict the future values of the sequence $\{Y_t\}$. The forecasts will be constructed using the advanced iteration method. It is important to note that the quality of the forecast declines as it continues.

[8] The statistical significance of any coefficient of autocorrelation is judged by its standard error. Bartlett showed that if a time series is purely random, that is, if it is a sample of white noise, the sample autocorrelation coefficients are approximately: $\rho k \sim N(0, 1/n)$.

Therefore, according to the properties of the standard normal distribution, the confidence interval of 95% for any (population) ρk es: $\rho k \pm 1.96(\sqrt{(1/n)})$.

[9] ME= (Mean Error) Error Medio; RMSE= (Root Mean Squared Error) Raíz Cuadrada del Error Cuadrático medio; MAE=(Mean Absolute Error) Error Absoluto Medio; MPE= (Mean Percentage Error) Error Medio Porcentual; MAPE=(Mean Absolute Percentage Error) Error Absoluto Medio Porcentual.

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**Validation of the forecast**

One way of knowing which of the selected models has the best performance to forecast is to develop a range of summary measures on the accuracy of the forecast based on the error measures. Ideally, it is desirable that forecast errors have an average close to zero and minimum variance. A Diebold-Mariano test (1995) must be carried out, in this test an objective function that is not quadratic is sought.

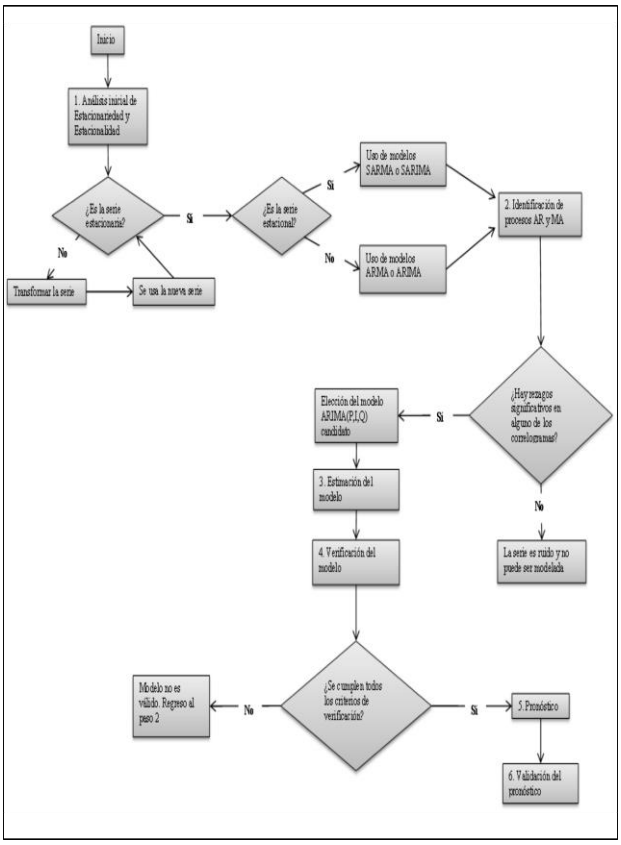


**Figure 1** Flowchart of the Box-Jenkins Methodology
*Source: self made*

## 5. Empirical Application for the Monetary Basis of Mexico

Next, we apply an algorithm based on the Box-Jenkinsmethodology to identify the behavior of the time series of the Mexican Monetary Base. With the help of several libraries belonging to the R system of statistical computing, the aim is to design a procedure that allows obtaining the optimal model, for which we will use one of the most important real variables of any economy, such as the Monetary Base.

Since the reform of the Bretton Woods agreement in 1976, it was established that exchange rate regimes would be determined flexibly by supply and demand. In this way, the creation of international liquidity remained in the hands of international financial markets. This agreement has generated international liquidity faster than the growth of the world economy and international trade (Mántey, 2013: 63). The disproportionate increase in the currency induces mainly speculative capital flows that perniciously burst from one economy to another, and mainly affecting the emerging economies.

International short-term capital flows cause volatility in exchange rates, in which emerging economies through their central banks must intervene in their foreign exchange markets in order to avoid strong appreciation of their currency and subsequently sterilize such interventions with which avoids inflationary pressures. Sterilization is the process by which the monetary authority ensures that interventions of the exchange rate will not affect the domestic monetary base, which is one of the components of the money supply in general. The accumulation of international assets has become the main support of the monetary base in the Mexican economy, while the share of domestic credit that the central bank grants to the government and commercial banks has been reduced.

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In the simplified balance sheet of any monetary authority, the monetary base is the sum of the credit of the central bank (government and commercial banks) plus its international reserves. In such a way that an increase in any of them will cause an increase in the money supply and vice versa. In a country like Mexico, determining the optimal economic policy in an environment of considerable income from speculative capital is a difficult task. Opting for a policy of intervention in the exchange market generates an increase in the currency of local currency, which could lead to a higher level of inflation, however, the Bank of Mexico can reduce these inflationary pressures by sterilizing interventions.

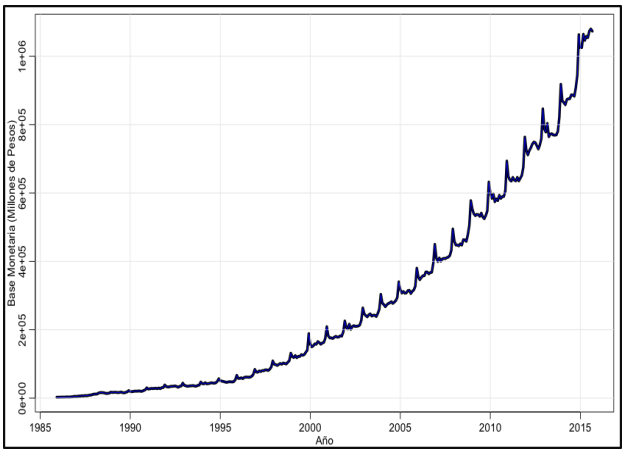
If inflation is high, sterilization of interventions may be necessary to meet a certain inflation target and not to affect the credibility of monetary policy (Borensztein, 2015: 13). On the other hand, Hüfner (2004) points out that, in developing countries, sterilized interventions can contribute to a better control of inflation than would be possible using the interest rate as the sole instrument of monetary policy. Any nation that adopts a fixed exchange rate regime or managed float, and also performs a continuous accumulation of international reserves, resulting in an increase in the monetary base, must inevitably rely on the exchange interventions made by its monetary authority as a means to maintain the stability of the exchange rate, and thereby achieve your inflation goal.

## Description of Data

The monetary base consists of the bills and coins in circulation and the total net balance of the current accounts that the credit institutions maintain in the Bank of Mexico. In our country the behavior of the monetary base is very similar to that of banknotes and coins in circulation because, as a rule, banks do not try to maintain positive balances in their accounts in the issuing institute (Banxico, 1998: 4).

The Bank of Mexico satisfies daily fluctuations in the demand for banknotes from the public. To do this, it has to create (buy currencies, securities and grant credit to commercial banks) or destroy (sell currencies, securities and become a debtor to the bank) monetary base, as the case may be. All the changes in the supply and demand of Monetary Base, are necessarily reflected in variations in the balances of the current accounts of the bank in the Bank of Mexico. To avoid pressure, the central institute balances the supply daily with the demand for monetary base through its daily interventions in the money market. This is done every working day from 12:00 hours (Banxico, 1998: 8).

The database from which the time series is compiled is: International Financial Statistics (IFS) of the International Monetary Fund. The periodicity is monthly and includes the period from December 1985 to September 2015, the units of the 358 data are given in millions of pesos, with this it is sought to have a considerable length in the database, which allows obtaining more estimates precise.




**Grph 1** Monetary Base of Mexico
*Source: Prepared by the author with data from the International Financial Statistics of the IMF*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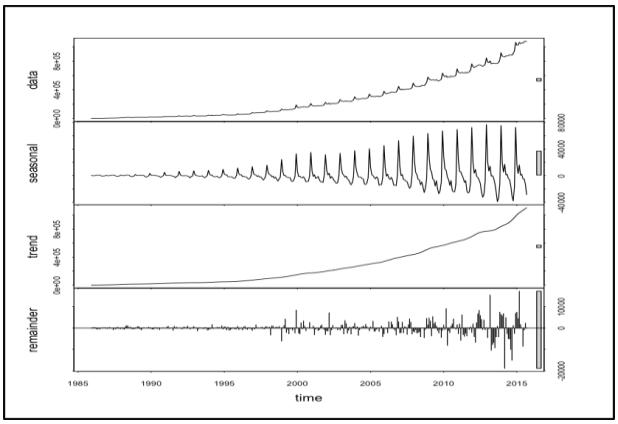
The monetary base (graph 1) presents a very defined seasonal pattern, through which it increases drastically towards the end of the year, when bonuses are paid and sales increase during the Christmas season. At the beginning of the cycle, demand decreases immediately and then suffers smaller variations. Even, it increases depending on the payment of the fortnights of the companies, the payment of taxes, the entrance of vacations and other effects of the calendar (Heath, 2012: 318).

## Estimation of the Box-Jenkins methodology

According to the Box-Jenkins methodology, in the first stage of the algorithm the Stationarity and Seasonality Analysis must be performed. Using the "stl" command we decompose the series into its components: trend, seasonality and noise (graph 2). What is observed is that the time series of the monetary base has a strong seasonal component, a clear positive trend and a remnant whose variation has increased since 1999. Likewise, the simple and partial correlograms were calculated and showed that the series behaves as non-stationary.




**Graph 2** Components of the time series of the Monetary Base
*Source: Own elaboration with R 3.3.3*

The Augmented Dickey Fuller test is also carried out in the algorithm to identify whether the time series has a unit root. Using the "urdfTest" command from the library "fUnitRoots" (Wuertz, 2009), it is verified that the Monetary Base is a non-stationary series. The "forecast" library developed by Hyndman (2008) provides the commands "ndiffs" and "nsdiffs" that allow estimating the number of differences required for a series of time to become stationary, in the same way the number of differences can be estimated seasonal The results of both tests indicate that the series must be differentiated ordinarily and seasonally, in both cases the order is one.

Considering the previous analysis, we proceed to stabilize the variance applying Neperian logarithms, the trend is eliminated by ordinary differentiation and the model is represented with a seasonal component. The results of the Augmented Dickey Fuller test are presented in Table 3.

| Variable | Condicionantes | Tau Statistic | p-value |
|---|---|---|---|
| Monetary base | Without Intercept | 4,5321 | NA |
| | Intercept | 2,8239 | NA |
| | Intercept and Trend | -0,1049 | 0,9165 |
| Δlog(Monetary base) | Without Intercept | -13,8685 | 0,0000 |
| | Intercept | -15,5037 | 0,0000 |
| | Intercept and Trend | -15,9514 | 0,0000 |

**Table 3** Augmented Dickey-Fuller test to identify Unitary Root
*Source: Own program elaboration R 3.3.3*

In the second stage of the algorithm, the simple and partial correlogram of the variable transformed with logarithmic differences are used, this allows to identify the pattern that represents the stochastic process, and in this way, to propose the appropriate ARIMA model. There is also a marked seasonal variation, which is present in the twelfth month of each year.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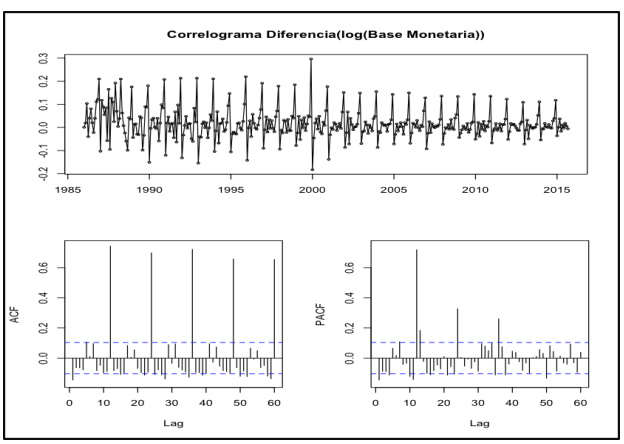
As already mentioned, the "forecast" library has the function "auto.arima" that allows defining the parameters p, d, q considering different information criteria such as Akaike (AIC, for its acronym in English) and Schwartz Bayesiano (BIC, for its acronym in English)[10], the latter will always select a more parsimonious model than the first one (Enders, 2015: 69).

For the time series of the Monetary Base of Mexico the function indicates that it is a model $SARIMA(0,1,2)x(0,1,3)_{12}$. This means that the stochastic process is represented by an order of integration one, a component of ordinary moving averages of order two and another component of seasonal integration, in addition to a component of seasonal moving averages of order three. The above corroborates what was established in the first stage, with respect to the strong presence of the seasonal component (graph 3).




**Grph 3** Function of Simple and Partial Autocorrelation of the Monetary Base
*Source: Own program elaboration R 3.3.3*

In the third stage of the algorithm, the estimated coefficients of the proposed model are presented, and two other possible models are presented to confirm that the stochastic process indicated by the "auto.arima" function effectively provides the optimal model for the time series. The method programmed in the algorithm is Maximum Likelihood.

| | **Dependent variable: Δlog(Monetary base)** | | |
|---|---|---|---|
| | **Model(1)** | **Model(2)** | **Model(3)** |
| | SARIMA (0,1,2)x(0,1,3)[12] | SARIMA (0,1,2)x(0,1,2)[12] | SARIMA (0,1,2)x(0,1,4)[12] |
| MA(1) | -0.2728*** | -0.2870*** | -0.2752*** |
| | -0,0555 | -0,0552 | -0,0556 |
| MA(2) | 0.1616*** | 0.1971*** | 0.1638*** |
| | -0,0566 | -0,0552 | -0,0564 |
| SMA(1) | -0.6031*** | -0.6003*** | -0.6136*** |
| | -0,0647 | -0,0625 | -0,0675 |
| SMA(2) | -0,1325 | 0,1702 | -0,1263 |
| | -0,0858 | -0,052 | -0,0931 |
| SMA(3) | 0,3419 | | 0.3231*** |
| | (0.0810)*** | | -0,0914 |
| SMA(4) | | | 0,0304 |
| | | | -0,0584 |
| Observations | 358 | 358 | 358 |
| AIC | 7077,98 | 7088,99 | 7079,71 |
| BIC | 7101,05 | 7108,21 | 7106,62 |
| log likelihood | -3532,99 | -3539,49 | -3532,86 |
| ME | 779,739 | 803,3763 | 778,3933 |
| RMSE | 6561,751 | 6737,466 | 6554,812 |
| MAE | 3980,888 | 4175,795 | 3968,208 |
| MPE | 0,2931 | 0,2877986 | 0,2931 |

**Table 4** Results of the SARIMA Regression (Maximum Likelihood)
*Source: Own program elaboration R 3.3.3*

Table 4 presents the results of the coefficients for the different proposals for stochastic processes. The model (1) is the one proposed as optimal, while model (2) has been constructed without considering the term of the seasonal moving average for month 36, and for the model (3).

[10] $\mathrm{AIC} = \mathrm{T} * \log(\mathrm{SRC}) + 2 * \mathrm{n}$
$\mathrm{BIC} = \mathrm{T} * \log(\mathrm{SRC}) + \mathrm{n} * \log(\mathrm{T})$
Where n= number of estimated parameters (p + q + constant term) and T= number of observations used.

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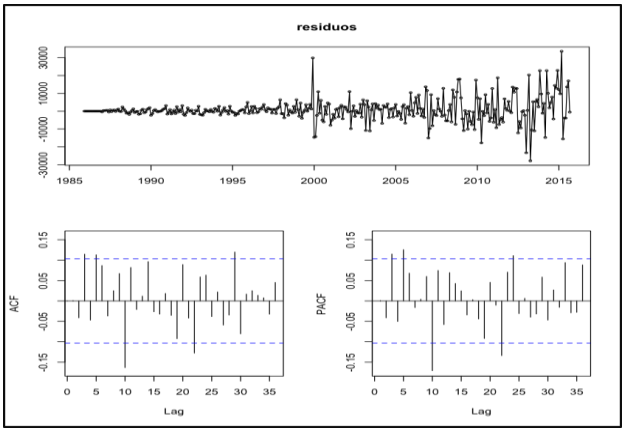
The same coefficients of the optimal model have been used but a seasonal moving average has been added that captures the value of the estimator corresponding to month 48. According to the Box-Jenkins methodology, in the next stage an analysis must be carried out to diagnose the goodness of fit of the optimal model, in the previous table the main statistics used in practice are recorded, based on the sum of quadratic residuals (SRC). It is evident that models (1) and (3) present the lowest values of these statistics (ME, RMSE, MAE, MPE), and that most of the estimated coefficients are in both cases statistically significant.

However, the information criteria of Akaike and Bayesiano indicate that the model that best estimates the true parameters is the model (1). We can identify that the two ordinary moving averages are statistically significant at a confidence level of 99%, while two of the three seasonal moving averages were statistically significant with very high confidence levels. It is also important to point out that the model does not present an intersection coefficient, this is because when this coefficient was included it was not statistically significant.

Additionally, since the model is explained by stationary stochastic processes, it is guaranteed to be stable. With the previous empirical evidence we proceed to graph the residuals of the selected model, its corresponding autocorrelation functions guarantee that it is a stationary process ( Graph 4 ). The previous thing is also corroborated with the unit root test of Dickey and Fuller in its three versions (-13.52, -13.79 and -14.11, without intercept, with intercept and with tendency and intercept, respectively), which indicates that the residuals of the optimal model are randomly distributed.




**Graph 4** FAC and FACP of the residues of the optimal model
*Source: Own program elaboration R 3.3.3*

To ensure that the residues of the optimal model behave independently, statistical algorithms were programmed in the algorithm to guarantee non-autocorrelation, the hypotheses were developed based on Box-Pierce and Ljung Box, both show that there is no autocorrelation in the first 5 lags Once all the criteria of the diagnosis have been verified, it is possible that the algorithm makes the forecast of the future values of the sequence that follows the Monetary Base.

## 6. Results

Once the compliance with the assumptions about the residuals of the optimal model and the other proposed models has been verified, they are calibrated to make forecasts for the next 9 months of the time series of the Mexican Monetary Base.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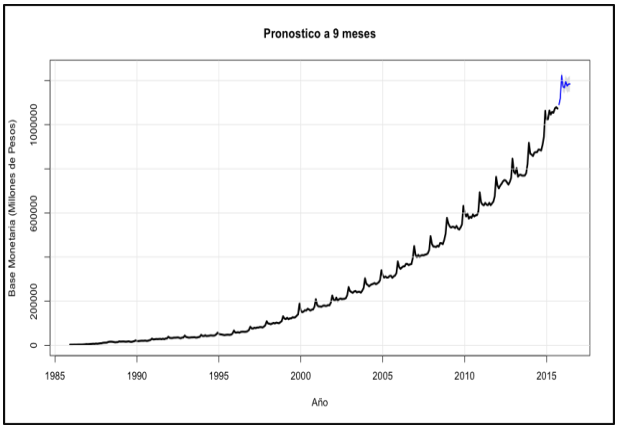


**Graph 5** Forecast for 9 months of the Monetary Base
*Source: Prepared by the author with the R program 3.3.3*

One way to identify which of the selected models has the best performance to forecast is to develop a range of summary measures on the accuracy of the forecast based on the error measures. Ideally, it is desirable that forecast errors have an average close to zero and minimum variance. However, if the difference in constructed forecasts is statistically significant, then it can not be efficiently diagnosed by the aforementioned measures.

To solve this problem the algorithm includes a modern method of statistical evaluation, known as the Diebold-Mariano test[11] (1995), that offers a quantitative evaluation tool of the accuracy of the forecast for the Monetary Base of Mexico.

| | DM test based on Model (2) and Model (1) | DM test based on Model (2) and Model (3) | DM test based on Model (1) and Model (3) |
|---|---|---|---|
| D-M statistics | 1,6851 | 1,8699 | 1,2341 |
| p-values | 0,04642 | 0,03116 | 0,109 |

**Table 5** Diebold-Mariano test

Note: The statistical test is based on Quadratic Absolute Errors, whose objective function is quadratic. Source: Prepared by the author with the program R 3.3.3

From table 5 the conclusions of the comparison of the models (1), (2) and (3) establish that according to the Diebold-Mariano test the statistic is 1.6851, which rejects the null hypothesis at the level of significance 5%, that is, the differences observed between the forecasts developed is significant and the accuracy of the forecast of the model (1) is better with respect to the model (2).

The same occurs with the test developed between the model (3) and the model (2), whose statistic is 1.8699, indicating that the model (3) provides a better fit than the model (2). Finally, the Diebold-Mariano test between models (1) and (3) shows that the statistic is 1.2341, so the null hypothesis can not be rejected at the 10% level of significance, that is, the difference observed between the Prognostics of both models is not statistically significant, noting that they have the same accuracy in the forecast. However, given that the AIC and the BIC (this criterion provides the most parsimonious model) they indicate that the optimal option should be the model (1), that is why it is used for the calculation of the forecast.

Then, table 6 shows the projection by interval of the 9 months after the last observed value, the lower and upper limits are calculated (Minimum and maximum value, respectively) of a range constructed with a confidence level of 95%, to calculate it, the point estimator (BM Forecast) was used as a center.

[11] The null hypothesis is that the two methods have the same accuracy in the forecast, while the alternative hypothesis is that method 2 is more accurate than method 1. (In R-Project: Alternative hypothesis = "greater").

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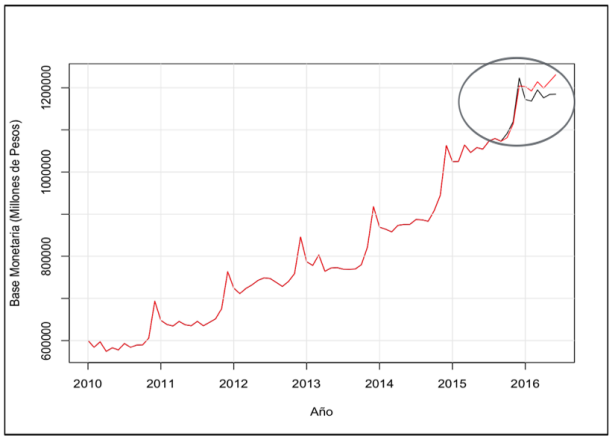
In addition, the true value recorded by the Mexican Monetary Base for the period of October 2015 to June 2016, provided by the Bank of Mexico, is presented. [12].

| Mes/Año | Minimum value | BM Forecast | Maximum value | Real Values |
|---|---|---|---|---|
| October 2015 | 1078469 | 1091666 | 1104863 | 1081587,28 |
| November 2015 | 1103176 | 1119493 | 1135810 | 1114508,08 |
| December 2015 | 1202934 | 1223029 | 1243124 | 1204344,70 |
| January 2016 | 1149077 | 1172345 | 1195613 | 1203142,75 |
| February 2016 | 1142278 | 1168334 | 1194391 | 1192508,08 |
| March 2016 | 1166495 | 1195070 | 1223644 | 1214379,10 |
| April 2016 | 1145245 | 1176133 | 1207021 | 1199118,36 |
| May 2016 | 1150987 | 1184027 | 1217067 | 1215015,55 |
| June 2016 | 1149587 | 1184646 | 1219706 | 1230752,88 |

**Table 6** Forecast Monetary Base of Mexico (Millions of Pesos)
*Source: Own elaboration with figures predicted with the R program 3.3.3. the Real Securities are taken from Banxico.*

According to the real values presented by Banxico, the prediction of the model (1) is quite accurate, the first three months are predicted effectively, while in the fourth month the prospection is outside the maximum limit for a level of confidence 95%, this is explained because, as expected, the forecasts are more accurate in the short than in the long term. However, the following 4 months, from February to May 2016, are also predicted within the established limits of significance, and finally the ninth month is again outside the maximum limit.

In general, we can establish that the algorithm works properly with regard to the optimal identification of the model, its calibration to estimate the coefficients of the different stochastic processes and the construction and verification of the forecast.




**Graph 6** Real Values vs. Predicted Values
*Source: Own program elaboration R 3.3.3*

Graph 6 shows the visual comparison between the real values and the predicted values, evidencing that there is a very good adjustment in the first months, practically the values overlap, and that later, despite the bias in the forecast of the fourth month the slopes positive and negative, which actually happened, were also correctly identified by the model built through the algorithm.

## 7. Conclusions

The present research shows that the proposed algorithm is effective in obtaining an accurate and reliable forecast for the first three months. The described procedure can be applied to different economic and financial variables to obtain reliable forecasts and thereby support decision making.

The forecasts obtained using the Box-Jenkins methodology have proven to be more reliable than those obtained from traditional econometric models, particularly in the case of short-term projections, as observed in the empirical application of this work.

[12] The data can be consulted at the following electronic address: http://www.banxico.org.mx/SieInternet/consultarDirectorioInternetAction.do?accion=consultarCuadro&idCuadro=CF104&sector=3&locale=es

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The adequate analysis, the correct identification, the calibration of the estimate, together with a clear validation, allow the optimal construction and verification of the forecast of a variable of vital importance for the Mexican economy, such as the monetary base, of the predicted behavior You can identify behaviors regarding the way in which the exchange and monetary policies in the Mexican economy are applied. Therefore, the subsequent work in this materia, will require adding to the forecast the exogenous variables that capture these behaviors.

A large proportion of the monetary base is offered during the intervention process in the currency market by the Bank of Mexico. To achieve the objectives of its monetary policy and alleviate inflationary pressures, the Central Bank intervenes in the foreign exchange market and at the same time actively adopts sterilization measures to neutralize the impacts of excess liquidity due to the increase in foreign currency reserves through changes Opposite in the net internal assets (internal credit of the Central Bank to the Government), this is evidenced by the clear pattern of constant growth of the money supply that has been presented and that is predicted to continue in the future. It is also clear that the sterilized intervention policy remains the tool through which the Central Bank achieves its goals of inflation targeting.

The constant growth of the monetary base shows that Banxico effectively sterilizes the impacts of speculative capital inflows and increases foreign exchange reserves in the national money supply. That is, the large-scale intervention of the foreign exchange market and the sterilization operations have a significant influence on Mexico's money supply.

In this context, it is evident that the current and predicted increase in the monetary base is aimed at maintaining the solvency of the banking system, the stability of the interest rate and the appreciation of the exchange rate to maintain internal and external balance. Consequently, the demand for the monetary base is determined by the needs for balance compensation between banks and the need for precautionary monetary balances, determined by the latter, by the bankers' state of trust (Mantey, 2004).

**Aknowledgement**

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## Codigo de Programación

```
#Titulo: Pronóstico de la Base Monetaria de México. Algortimo para la
  metodología Box-Jenkins
#Programa R por Eduardo Rosas Rojas; Última revisión: Abril 2017.
library(urca); library(forecast); library(zoo); library(lmtest);
  library(sandwich);library(fUnitRoots); library(tseries)
#-----------------------------------------------------------------------
# Importación de datos y transformación.
rm(list=ls())
print(paste("Ejecutado en: ", date()))
BM<-read.csv(file.choose(), header=T)
attach(BM)
bm<-ts(BM[,2],start=c(1985,12),freq=12)
#Se ha guardado la serie de tiempo, se reproduce con c: BM.csv
#-----------------------------------------------------------------------
#Paso 1: Análisis de Estacionariedad y Estacionalidad
# Descomposición de la serie en sus componentes :  tendencia,
  estacionalidad y ruido.
plot(stl((bm), s.window=4, t.window=12))
# Correlograma simple y correlograma parcial
tsdisplay(bm, lag.max=60, main = "Correlograma Base Monetaria")
#Prueba de Raíz unitaria
urdfTest(bm, lags = 1, type = c("nc"), doplot = T)
urdfTest(bm, lags = 1, type = c("c"), doplot = T)
urdfTest(bm, lags = 1, type = c("ct"), doplot = T)
#Identificación del número de diferencias ordinarias
ndiffs(bm, alpha=0.05, test=c("adf"), max.d=2)
# Identificación de diferencias estacionarias.
nsdiffs(bm, m=12, test=c("ocsb"), max.D=2)
#Transformación de diferencias logarítmicas y sus respectivas pruebas
dlbm<-diff(log(bm))
plot(stl((dlbm), s.window=4, t.window=12))
tsdisplay(dlbm, lag.max=60, main = "Correlograma Diferencia(log(Base
  Monetaria))")
urdfTest(dlbm, lags = 1, type = c("nc"), doplot = F)
urdfTest(dlbm, lags = 1, type = c("c"), doplot = F)
urdfTest(dlbm, lags = 1, type = c("ct"), doplot = F)
#-----------------------------------------------------------------------
#Paso 2:  Identificación del proceso ARIMA
# R cuenta con la función "auto.arima" del paquete "forecast" la cual
  selecciona automáticamente el orden del proceso ARIMA minimizando el
  Criterio AIC y/o BIC
arima_x=auto.arima(bm, max.p=12, max.q=12, max.P=12, max.Q=12,
  max.d=2, max.D=1, start.p=2, start.q=2, start.P=1,
  start.Q=1,stationary=FALSE , seasonal=FALSE,
  ic=c("bic"),stepwise=TRUE, test=c("kpss"), seasonal.test=c("ocsb"))
arima_x
# "auto.arima" indica un proceso SARIMA (0,1,2)X(0,1,3)[12]
#-----------------------------------------------------------------------
# Paso 3: Estimación del modelo (modelos)
# Usamos el comando "Arima "para realizar inferencia estadística; se
  especifica el modelo obtenido en el Paso 2, y otros dos modelos
  propuestos.
model1 <- summary(bm.arima<-Arima(bm, order=c(0,1,2),
  seasonal=c(0,1,3),include.mean=T, include.drift=F, include.constant=F,
  method=c("ML")))
model2<-summary(bm.arima1<-Arima(bm, order=c(0,1,2),
  seasonal=c(0,1,2),include.mean=T, include.drift=F, include.constant=F,
  method=c("ML")))
model3<-summary(bm.arima2<-Arima(bm, order=c(0,1,2),
  seasonal=c(0,1,4),include.mean=T, include.drift=F, include.constant=F,
  method=c("ML")))
#-----------------------------------------------------------------------
#Paso 4: Verificación del Modelo.
#Se grafican los residuos del modelo óptimo, sus correlograma Simple y
  Parcial, se aplica un a prueba de raíz unitaria, y otra prueba de No
  autocorrelación.
residuos<-(residuals(bm.arima))
tsdisplay(residuos)
urdfTest(residuos, lags = 1, type = c("nc"), doplot = F)
urdfTest(residuos, lags = 1, type = c("c"), doplot = F)
urdfTest(residuos, lags = 1, type = c("ct"), doplot = F)
Box.test(residuos, lag=1, type="Ljung")
Box.test(residuos, lag=2, type="Ljung")
Box.test(residuos, lag=3, type="Ljung")
Box.test(residuos, lag=4, type="Ljung")
Box.test(residuos, lag=1, type="Box")
Box.test(residuos, lag=2, type="Box")
Box.test(residuos, lag=3, type="Box")
Box.test(residuos, lag=4, type="Box")
# Se sigue el mismo procedimiento para los otros dos modelos
#-----------------------------------------------------------------------
# Paso 5: Pronóstico
# Pronosticamos 3, 6, y 9 meses (método recursivo) con intervalos al 95%
  de confianza. Se grafican los diferentes pronósticos
```


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```
bmarimaf3 = forecast(bm.arima, h=3, level=c(95))
bmarimaf6 = forecast(bm.arima, h=6, level=c(95))
bmarimaf9 = forecast(bm.arima, h=9, level=c(95))
par(mfrow = c(3,1))
plot(bmarimaf3, main = "Horizonte=3")
plot(bmarimaf6, main = "Horizonte=6")
plot(bmarimaf9, main = "Horizonte=9")
par(mfrow= c(1,1))
plot(bmarimaf9, ylab='Base Monetaria (Millones de Pesos)', xlab='Año' ,
  type='l', lwd="3", main = "Pronostico a 9 meses")
grid(lty=1, col=gray(.9))
summary(bmarimaf9)
# Se obtiene el pronóstico puntual y por intervalo.
#-----------------------------------------------------------------------------
#Paso 6. Validación del Pronóstico
#Se aplica la prueba Diebold-Mariano para identificar el modelo que
  proporciona el pronóstico óptimo.
f1<-bm.arima<-Arima(bm, order=c(0,1,2),
  seasonal=c(0,1,3),include.mean=T, include.drift=T, include.constant=F,
  method=c("ML"))  #Dado que el comando auto.arima nos señala que el
  modelo tiene deriva, colocamos "include.drift=T"
f1p<-forecast(bm.arima, h=9, level=c(95))
f2<-bm.arima1<-Arima(bm, order=c(0,1,2),
  seasonal=c(0,1,2),include.mean=F, include.drift=F, include.constant=T,
  method=c("ML"))
f2p<-forecast(bm.arima1, h=9, level=c(95))
f3<-bm.arima1<-Arima(bm, order=c(0,1,2),
  seasonal=c(0,1,4),include.mean=F, include.drift=F, include.constant=T,
  method=c("ML"))
f3p<-forecast(bm.arima2, h=9, level=c(95))
accuracy(f1p)
accuracy(f2p)
accuracy(f3p)
dm.test(residuals(f2p),residuals(f1p),h=9, alternative=c("greater"),
  power=2)
dm.test(residuals(f2p),residuals(f3p),h=9, alternative=c("greater"),
  power=2)
dm.test(residuals(f1p),residuals(f3p),h=9, alternative=c("greater"),
  power=2)
summary(bmarimaf9)
#-----------------------------------------------------------------------------
```


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# Instructions for authors

A. Submission of papers to the areas of analysis and modeling problems of the:

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- Macroeconomics: Consumption, saving, production, employment and investment
- Prices, fluctuations and economic cycles
- Money and interest rates
- Configuring macroeconomic policy, macroeconomic aspects of public finances, macroeconomic policies and general Outlook

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Text in Times New Roman No.12, single space.

General explanation of the subject and explain why it is important.

What is your added value with respect to other techniques?

Clearly focus each of its features

Clearly explain the problem to be solved and the central hypothesis.

Explanation of sections Article.

**Development of headings and subheadings of the article with subsequent numbers**

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**Including graphs, figures and tables-Editable**

In the article content any graphic, table and figure should be editable formats that can change size, type and number of letter, for the purposes of edition, these must be high quality, not pixelated and should be noticeable even reducing image scale.

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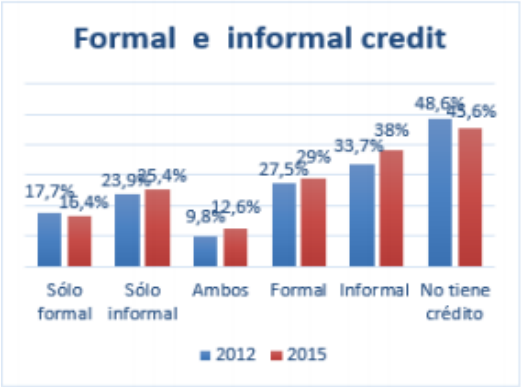


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| | Final demand :entration Inde 2013 | | Change on inal demand oncentration :xes. 2003-2013 | | Total hange :ribution |
|---|---|---|---|---|---|
| | 8 ctors | 4 ctors | 8 ctors | 4 ctors | 4 /8 :ctors |
| Average | | | | | |
| Regions | 43.0% | 29.0% | 9.2% | 7.6% | 83.1% |
| States | 44.5% | 30.6% | 10.7% | 8.9% | 82.9% |
| National | 43.9% | 32.1% | 9.7% | 8.4% | 86.2% |
| Extreme values on ons | | | | | |
| Maximum a | 50.8% | 37.7% | 10.2% | 9.4% | 91.5% |
| Minimum b | 38.0% | 23.4% | 7.8% | 6.7% | na |
| Extreme values on s | | | | | |
| Maximum c | 67.2% | 59.8% | 18.9% | 18.5% | 97.7% |
| Minimum d | 18.5% | 6.6% | 4.8% | 4.0% | 82.4% |

a Northeast region in all cases
b South, West, Central-North Plateau, respectively
c Tabasco, Tabasco, Sonora and Sonora, respectively
d Campeche, Puebla, Guanajuato y Guanajuato, respectively

**Table 1** Title and Source (in italics**).**

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