Professor Ernesto LEON CASTRO, M.Sc.
E-mail: ernesto.leon@udo.mx
Universidad de Occidente, México
Professor Ezequiel AVILÉS OCHOA, PhD
Universidad de Occidente, México
Professor Anna Maria GIL LAFUENTE, PhD
Universidad de Barcelona, España

EXCHANGE RATE USD/MXN FORECAST THROUGH ECONOMETRIC MODELS, TIME SERIES AND HOWMA OPERATORS

Abstract. *This paper aims to provide models that can predict the exchange rate and generate future scenarios of this variable, this because exchange risk management has become a strategic activity of the corporate governance. Also the study aims to expand the uses of operators like Heavy Ordering Weight Moving Average (HOWMA) in different fields of economy and management.*

Design/methodology/approach. *In this work three fundamental econometric models were used to forecast exchange rate USD/MXN, using 1994 to 2014 data, which are price index, interest rate and balance of payments. Additionally, two variables forecasting techniques were used; these are time series and HOWMA.*

Findings. *Among the results it was found that both methods are effective in middle term forecast, the last one being the one that can introduce uncertainty, expectations of the economy and characteristics of the decider into the models, enabling a range of possible scenarios.*

Keywords: *Exchange rate forecast, Econometric models, Time Series, HOWMA operators.*

JEL Classification: F31, C51, C22, C53

1. Introduction

Because the high volatility of the exchange rate points Majhi, Panda &Sahoo(2009) it is necessary to generate models that predict the future of it. In this regard Engel, Mark & West (2007) state that the exchange rate is a reflection of basic macroeconomics, as the interest rate, purchasing power parity and trade balance.

The fundamental models to forecast exchange rate is unstable and have not been successful in short term, Cheung*et al.* (2005) found that exchange rate follows a random walk behavior better than models based on macroeconomic fundamentals as the purchasing power parity, parity of interest rate and simple versions of monetary models. For their part Engel*et al.*(2007) found some success in determining the exchange rate in the long term using these variables.

One of the limitations of traditional models to forecast exchange rate, indicate Phillips(2003) and Boyer & Young(2005) is using variables whose behavior is complex, so it is based on simple assumptions of the future behavior of them, so the result is a reflection of the conditions used and exist a possibility of different scenarios.

In this sense it is necessary to use models in which accurate data is not used, because these become ineffective in situations of uncertainty (Gil Aluja, 2004). So considering the opinion of the currency market experts within the models will allow assumes different expectations of the future (Chen, 2011).

In this work, three econometric models based on macroeconomic fundamentals were used, additionally two different techniques for the prediction of each of the variables, time series and operators Heavy Ordering Weight Moving Average (HOWMA), looking to forecast the exchange rate USD/MXN for 2015.

The remainder of the paper is organized as follows. In Section 2, we review some theories of exchange rate determination and techniques used in the paper. In Section 3, we make a brief description of the importance of exchange rate USD/MXN in Mexico. In Section 4, the results of the application of the models is presented. Finally, Section 5 summarized the main conclusions of the paper.

2. Methodological approach

The basic concepts that should be known in the current investigation are as follows

Definition 1. The theory of Parity Purchasing Power (PPP), indicate Taylor & Taylor(2004) say that exchange rate between two currencies is determined by the change in the price level of the two countries. So that exchange rate adjusts to the inflation differentials. In this way the formula of PPP is:

$$\mathrm{TC_F} = \beta_0 + \beta_1 \mathrm{PI}_F + \beta_2 \mathrm{PI_D}\ , \tag{1}$$

where $\mathrm{TC_F}$ is future exchange rate, $\mathrm{PI_F}$ is foreign price index y $\mathrm{PI_D}$is domestic price index.

Definition 2. The theory of Interest Rate Parity (IRP), said McCallum(1993) that in free money markets, the spread of interest rates should equal the discount or premium future, so there is parity if the difference between interest rates offsets the forward premium of the stronger currency. So the mathematical relation is:

$$TC_F = \beta_0 + \beta_1 I_F + \beta_2 I_D \quad , \tag{2}$$

where TC_F is future exchange rate, I_F is foreign interest rate and I_D is domestic interest rate.

Definition 3. The theory of the Balance of Payments (BoP), raises Dornbusch(1979) that the exchange rate is adjusted to the balance of inflows and outflows from international transactions in goods, services and assets, so that the current account is affected by the exchange rate due to relative Price changes and hence the competitiveness, the capital account on the other hand is affected by expectations of investors and interest rate. The formula that explains this phenomenon is:

$$TC_F = \beta_0 + \beta_1 CAB + \beta_2 FIP + \beta_3 DFI + \beta_4 R \ , \tag{3}$$

where TC_F is future exchange rate, *CAB* is current account balance, *FIP* is foreign investment in portfolio, *DFI* is direct foreign investment y *R* reserves account.

Definition 4. The time series models that express a variable can be decomposed into four elements that are the trend, seasonality, cycle and irregularities, which can be expressed in the following multiplicative form (Fischer & Planas, 2000).

$$Y_t = T_t * S_t * I_t \quad , \tag{4}$$

where Y_t is observed value, $T_t$is trend, S_t is seasonality, C_t is cycle y I_t is irregularity

Definition 5. Moving averages, according to Kenney & Keeping(1962), are defined as a given sequence $\{a_i\}_{i=1}^{N}$, where a moving average n is a new sequence $\{s_i\}_{i=1}^{N-n+1}$ defined from de a_i taking the arithmetic mean of the sequence of n terms, such that

$$s_i = \frac{1}{n} \sum_{j=i}^{i+n-1} a_j \ , \tag{5}$$

so a sequence s_n given a moving average n will be

$$S_2 = \frac{1}{2}(a_1 + a_2, a_2 + a_3, \dots, a_{n-1} + a_n),$$

$$S_3 = \frac{1}{3}(a_1 + a_2 + a_3, a_2 + a_3 + a_4, \dots, a_{n-2} + a_{n-1} + a_n) \ ,$$

and so on.

Definition 6. The ordered weighted averaging(OWA) operators developed by Yager(1988) allow the decision-maker subject to add information from a data set, in order to obtain a representative of the same value. In this respect an OWA operator of dimension $n$is a mapping$F: R^n \rightarrow R$ with an associated weight vector $w = [w_1, w_2, \dots, w_n]^T$ thereby $w_j \in [0, 1]$, $1 \leq i \leq n$ and

$$\sum_{i=1}^{n} w_i = w_1 + w_2 + \cdots + w_n = 1\ , \tag{6}$$

where

$$F(a_1, a_2, \dots, a_n) = \sum_{k=1}^{n} w_j\, b_j\ , \tag{7}$$

being b_j the jth largest element of the collection $a_1 a_2, \dots, a_n$.

Definition 7. A heavy aggregation operator, points Yager(2002) and Merigo& Casanovas (2011) is an extension to OWA operator that allows the weight vector goes up to n. So a HOWA operator is a mapping $R^n \rightarrow R$ which are associated to a weight vector *w* which $w_j \in [0,1]$ y $1 \leq \sum_{j=1}^{n} w_j \leq n$, so that

$$HOWA\ (a_1, a_2, \dots, a_n) = \sum_{j=1}^{n} w_j b_j\ , \tag{8}$$

being b_j is the *j*th element largest of the collection $a_1 a_2, \dots, a_n$.

Definition 8. A HOWMA is defined as a sequence given $\{a_i\}_{i=1}^{N}$, where you get a new sequence $\{s_i\}_{i=1}^{N-n+1}$ which is multiplied by the heave weight vector, so that

$$HOWMA(s_i) = \sum_{j=1}^{n} w_j b_j\ , \tag{9}$$

being b_j is the *j*th element largest of the collection s_i.

2.1.1 Considerations

In this research various econometric models were used in order to predict the exchange rate USD/MXN, for this multiple linear regression model were used, where exchange rate was dependent variable and for independent variables were used price index, interest rates and balance of payments (Tsai, 2012; Razmi*et al.*, 2012).

Among the problems encountered in the use of multiple liner regression models for determining a dependent variable is the existence of non-constant variation in the variables. One way to fix it is by transforming the data, which is generating new information using the logarithm of the original variables and generate the model with that data (Bartram & Bodnar, 2007).

Finally, a characteristic of the exchange rate as a variable, is that the changes from month to month are only partial, since the change for next month will be based on the end of the previous month, so that the model should be smoothing using the same variable with a lag in the model (Engel *et al.*, 2007).

3. Exchange rate USD/MXN

The result of 1994 crisis in Mexico, expressed Cartens & Werner(2000), forced to leave the default floating regime and adopt a free floating regime against the various world currencies. Those responsible for the fluctuations in the price of currencies, claim Ghosh, Ostry, & Chamon(2015) are the changes in supply and demand of financial markets, influenced by numerous external factors and the regime of free float, which creates a kind of unexpected, obscure and volatile change that threatens the future cash flows of the companies. (Bartram & Bodnar, 2012).

The effect of adopting the system of free floating exchange rate has generated considerable uncertainty in the value of currencies in Mexico, mainly in the exchange rate USD/MXN which from 1994 to 2014 has faced a high variation in price and volatility (See figure 1 and 2).

Currency risk exposure, expressed Chaney(2013) and Chatterjee, Dix-Carneiro, & Vichyanond(2013) is linked to the daily operations of the company, among which include imports, exports, investment and foreign currency loans. In that way foreign exchange risk, note Wu & Chang(2012) leads decision makers to accurately measure the exchange rate, in that way design strategies to reduce it to acceptable levels, that is why determine the future exchange rate becomes necessary.

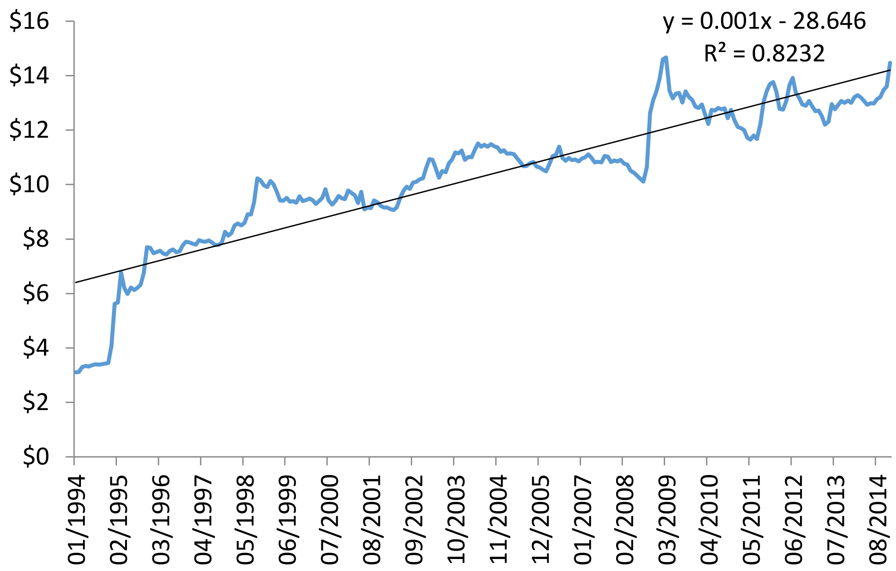

Figure 1. Spot exchange rate USD/MXN 1994-2014

Source: Own elaboration with data from Banxico (2015)

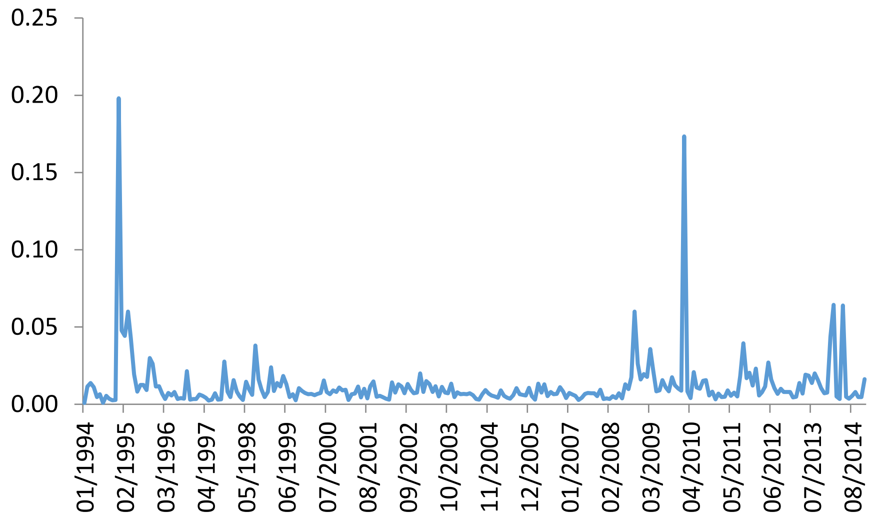

Figure 2. Exchange rate volatility USD/MXN 1994-2014
Source: Own elaboration with data from Banxico (2015)

4. Application of the model

Preliminary considerations

For the PPP and IRP model a data transformation was used, changing the original values with the logarithm of the same. In the BoP model such process was not performed because the current account balance and foreign investment has negative data so it is not possible to use logarithm. Within each model two additional variables were added, the first one is the exchange rate with a lag, this in order to smooth the model, and the second is volatility, in order to identify the effect this has within the forecast rate.

Fundamental econometric models

The information used to generate each of these models were from 1994 to 2014 data for each variable that integrated the model, obtaining the following models

PPP model

$$tc_F = 0.107 + 0.914tc_{-1} + 0.0235v - 0.00195pi_F + 0.0408pi_D \tag{10}$$

IRP model

$$tc_F = 0.0908 + 0.960tc_{-1} + 0.0225v - 0.000019i_F - 0.00228i_D \quad (11)$$

BoP model

$$TC_F = 0.175 + 0.978TC_{-1} + 4.59V - 0.000041CAB - 0.000023FIP - 0.000016DFI + 0.000002R \quad (12)$$

Where tc_F is future exchange rate, tc_{-1} is spot exchange rate with one lag, *v* is volatility, pi_F is foreign price index, $pi_D$is domestic price index, i_F is foreign interest rate, i_D is domestic interest rate, where all of the above variables are expressed in logarithm, TC_F is future exchange rate, , TC_{-1} is future exchange rate with one lag, *V* is volatility, *CAB* is current account balance, *FIP*is foreign investment in portfolio, *DFI* is direct foreign investment y Ris reserved account.

Econometric analysis

Significance test individual and joint

To each of the models the P value is used to determine the significance of each of the variables under the following assumptions

1. H_0 is accepted if the P value is higher than 0.05

1. H_0 is rejected if the P value is lower than 0.05

Using P value to determine the significance of each of the variables for each model it was found that within the PPP model, exchange rate with a lag and domestic price index are rejected, but the null hypothesis was accepted for constant, volatility and foreign price index (See annex 1)

Within IRP model the null hypothesis is rejected for constant, exchange rate with a lag and volatility, but is accepted for foreign interest rate and domestic interest rate (See annex 2). Finally, for the BoP model the null hypothesis is rejected for exchange rate with a lag, volatility, foreign investment in portfolio and direct foreign investment and is accepted for constant and current account balance (See annex 3).

For the significance test for the entire models, we find that the null hypothesis for each of them is rejected, meaning that all have accepted significance considering all the variables (See annex 4)

Autocorrelation residues test

With the analysis of Durbin-Watson to determine if exist autocorrelation within the residues, it is found that PPP, IRP and BoP model have no autocorrelation in their residues. (See annex 5)

Multicollinearity Test

For this test variance inflation factors were used. Within the PPP model was found that exchange rate with a lag has low multicollinearity, volatility moderate and foreign price index and domestic price index have high. (See annex 6)

For IRP model by analyzing the variance inflation factors is detected that exchange rate with a lag and volatility have low multicollinearity, instead foreign interest rate and domestic interest rate have high. (See annex 7). Finally, balance of payments has low multicollinearity for all the variables. (See annex 8).

Forecast of the variables

For forecast every variable first it was used multiplicative decomposition time series method, in which determine the type of tendency and its equation, further seasonality, cycle and irregularities for each of the months of the year. (See annex 9)

Moreover, HOWMA operators were used to forecast the future of the variables in which a sequence $n = 6$ was used, this because the decision maker believes that this are the months that still hold important information for the forecast. Additionally, consider a $w = 1.05$, this is due the economic scenario for the 2015 was negative, so the exchange rate USD/MXN will depreciate with a valuation for each of the six months in the moving averages as follow $w = (0.05{,}0.15{,}0.15{,}0.25{,}0.40)$, also a maximization criterion was used in the result, that is the scenario that leads to greater exchange rate depreciation. All this based on the information provided by the decision maker.

The result of econometric models with time series and operators HOWMA are seen in Table 1 and 2 respectively.

Table 1. Forecast of exchange rate using econometric models and time series

Time	Spot Exchange rate	PPP model	Error	IRP model	Error	BoP model	Error
01-15	14.6808	15.6757	0.9949	15.6435	0.9627	15.5804	0.8996
02-15	14.9230	15.6272	0.7042	15.5716	0.6486	15.8417	0.9187
03-15	15.2136	15.2111	-0.0025	15.1264	-0.0872	15.3650	0.1514
04-15	15.2208	15.2666	0.0458	15.1832	-0.0376	15.3671	0.1463
05-15	15.2475	15.4326	0.1851	15.3492	0.1017	15.5471	0.2996
06-15	15.4692	15.7162	0.2470	15.6489	0.1797	15.8292	0.3600
07-15	15.9225	15.8889	-0.0336	15.8342	-0.0883	15.9158	-0.0067
08-15	16.5032	15.6731	-0.8301	15.6062	-0.8970	15.6174	-0.8858
09-15	16.8519	15.6922	-1.1597	15.6222	-1.2297	15.7823	-1.0696
10-15	16.5813	15.8258	-0.7555	15.7580	-0.8233	15.6008	-0.8905
Average Errors	15.6614	15.6009	0.0604	15.5343	-0.1271	15.6637	-0.0077

Table 2. Forecast of exchange rate using econometric models and HOWMA

Time	Spot Exchange rate	PPP model	Error	IRP model	Error	BoP model	Error
01-15	14.6808	14.4197	- 0.2611	14.4255	-0.2553	14.5448	-0.1360
02-15	14.9230	14.4971	-0.4259	14.4952	-0.4278	14.5601	-0.3629
03-15	15.2136	14.8056	-0.4080	14.8092	-0.4044	14.8402	-0.3734
04-15	15.2208	15.1007	-0.1201	15.1098	-0.1110	15.1268	-0.0940
05-15	15.2475	15.4455	0.1980	15.4622	0.2147	15.4882	0.2407
06-15	15.4692	15.7565	0.2873	15.7792	0.3100	15.7913	0.3221
07-15	15.9225	16.0647	0.1422	16.0965	0.1740	16.1272	0.2047
08-15	16.5032	16.3817	-0.1215	16.4208	-0.0824	16.4509	-0.0523
09-15	16.8519	16.7113	-0.1406	16.7585	-0.0934	16.7916	-0.0603
10-15	16.5813	17.0465	0.4652	17.1021	0.5208	17.1385	0.5572
Average Errors	15.6614	15.6229	-0.0384	15.6459	-0.0155	15.6860	0.0246

5. Conclusions

Globalization, open markets and free floating regime of exchange rate has generated great expectations for companies on the future of the various types of changes. In the case of Mexico's economy, the effect of the USD/MXN exchange is considerable, so is necessary to generate scenarios about the future behavior of the same that let make strategies and decisions within this environment of uncertainty.

In this research three traditional econometric models, PPP, IRP and BoP were used to determine the exchange rate USD/MXN, additionally time series and HOWMA were used to detect the future of each one of the variables that compose the models.

The results show that both techniques have problems detecting shot term exchange rate, but analyzing the medium term with the average error can be seen that is very low, so that econometric models using time series and HOWMA are efficient under these scenarios.

Finally, it is noted that forecast with time series generate one result, leaving aside the possibility of make different scenarios according to the characteristics of the decision maker and changes in the economic expectations among months, but with the HOWMA operators we can add this information to the models, allowing them to adapt to these uncertain scenarios. Future research will be made using different aggregation operators such probabilistic, generalized, induced, among others, as the inclusion of expertons for generating a weight vector more efficiently. (e.g. Blanco-Mesa, Gil-Lafuente, & Merigó(2015)).

ANNEXES

Annex 1. Significance test for PPP model

Variable	P Value	Accept or Reject H_0
Constant	0.131	Accept
tc_{-1}	0.000	Reject
v	0.625	Accept
pi_F	0.066	Accept
pi_D	0.000	Reject

Annex 2. Significance test for IRP model

Variable	P Value	Accept or Reject H_0
Constant	0.000	Reject
tc_{-1}	0.000	Reject
v	0.000	Reject
i_F	0.627	Accept
i_D	0.917	Accept

Annex 3. Significance test for BoP model

Variable	P Value	Accept or Reject H_0
Constant	0.066	Accept

tc_{-1}	0.000	Reject
v	0.000	Reject
CAB	0.052	Accept
FIP	0.000	Reject
DFI	0.020	Reject
R	0.001	Reject

Annex 4. Significance test for the entire model

Model	P Value	Accept or Reject H_0
PPP model	0.000	Reject
IRP model	0.000	Reject
BoP model	0.000	Reject

Annex 5. Durbin-Watson test for the residues of the models

Model	Durbin Watson	Result with 1% of significance	Result with 5% of significance
PPP model	1.9071	Without autocorrelation	Without autocorrelation
IRP model	1.93561	Without autocorrelation	Without autocorrelation
BoP model	1.91376	Without autocorrelation	Without autocorrelation

Annex 6. Variance inflation factors for PPP model

Variable	VIF	Multicollinearity
tc_{-1}	1.077	Low
v	8.970	Moderate
pi_F	28.287	High
pi_D	12.424	High

Annex 7. Variance inflation factors for IRP model

Variable	VIF	Multicollinearity
tc_{-1}	1.853	Low
v	1.153	Low
i_F	3.229	Moderate
i_D	3.018	Moderate

Annex 8. Variance inflation factors for BoP model

Variable	VIF	Multicollinearity
TC_{-1}	2.684	Moderate
V	1.034	Low
CAB	1.027	Low
FIP	2.172	Moderate
DFI	1.391	Low
R	3.644	Moderate

Annex 9. Trend type and formula for variables

Variable	Type of trend	Trend formula
TC_{-1}	Exponential	$6.3461 * 1.00352^t$
V	Exponential	$0.007 * 1.00125^t$
PI_F	Exponential	$147.085 * 1.00201^t$
PI_D	Exponential	$31.0370 * 1.00601^t$
i_F	Exponential	$16.359 * 0.978471^t$
i_D	Exponential	$29.3549 * 0.990829^t$
CAB	Quadratic	$-17 - 10.13t + 0.0402t^2$
FIP	Quadratic	$-157 - 17.7t + 0.2128t^2$
DFI	Exponential	$2840.4 * 1.00396^t$
R	Exponential	$13603.4 * 1.01074^t$

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