FOREIGN EXCHANGE INTERVENTION IN MEXICO: EVIDENCE FOR THE SIGNALLING CHANNEL

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Resumen

Este trabajo de investigación analiza el efecto que tuvieron las intervenciones del banco central sobre las expectativas del tipo de cambio vía el canal de señalamiento. Luego de examinar las principales bases teóricas de denominado canal de señalamiento, se estimó una ecuación de regresión usando el tipo de cambio forward como una proxy de las expectativas de los inversionistas. La regresión fue realizada para medir el efecto a un mes, tres meses y un año, sobre las expectativas de los inversionistas. Uno de los principales resultados es que el canal de señalamiento parece influir en las expectativas de los inversionistas a un año, más que a un mes o tres meses.

Palabras clave: *Intervenciones del banco central, canal de señalamiento, tipo de cambio forward, expectativas del inversionista.*

Abstract

This research paper analyzes the effect that central bank interventions had on exchange rate expectations via the signaling channel. After an examination of the main theoretical underpinnings of the signaling channel, a regression equation was estimated using the forward exchange rate as a proxy for investor expectations. The regression was carried out to measure the effect for 1 month, 3 month and 1 year investor expectations. One of the main results is that the signaling channel appeared to influence 1 year more than 1 month or 3 month investor expectations.

Keywords: *Central bank interventions, signalling channel, forward exchange rate, investor expectations.*

INTRODUCTION

In the decades following the financial crisis of 1995 in Mexico, the Foreign Exchange Comission (FEC), which is formed by the central bank of Mexico (Banxico) and Secretaria de Hacienda y Credito Público (SHCP), carried out the task of setting guidelines for exchange rate policy, along with implementing institutional reforms and policies aimed at strengthening Mexico´s position in the foreign exchange market. One of the aims of the new policies was to increase the policy and institutional credibility of the

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[1] Los puntos de vista expresados en este documento corresponden únicamente a los autores y no necesariamente reflejan las ideas del ITESM.

central bank in the eyes of economic actors.

The financial crisis of 2008 took many central banks around the world by surprise, including Banxico. As investors and companies retrieved dollars from the foreign exchange market, the exchange rate (in terms of pesos per dollar) started to increase drastically at a swift rate. Upon this rapid depreciation of the Mexican peso (MXN) against the US dollar (USD), from around $10.45 before the crisis to a historic $15.47 on its worse day, exchange rate intervention by the FEC was imminent. An official exchange rate intervention in the foreign exchange market occurs when the authorities buy or sell foreign exchange, normally against their own currency and with the purpose of influencing the exchange rate or moderating exchange rate volatility Sarno and Taylor (2001, 839) Intervention is defined as official purchases and sales of foreign exchange to achieve one or more of the following four objectives: correct exchange rate misalignment, moderate exchange rate volatility, accumulate reserves and supply foreign exchange to the market Guimares, & Karacadag (2004).

The objective of the Mexican Central Bank (Banxico) was primarily to reduce volatility and provide liquidity during the period of 2008 when the financial crisis struck. It intended to do this by intervening in the foreign exchange market during several periods and through different mechanisms with a massive supply of dollars, canalized in the banking system through auctions. This intervention signified a new system compared to past policies.

There has been a long lasting dispute among policy makers and academics regarding the intervention of monetary authorities to influence the level and volatility of foreign exchange rates. The standard theoretical framework establishes that intervention can be effective through three different channels: the portfolio balance channel, expectations or signalling channel and the microstructure or order flow channel. The signalling channel is a mechanism through which the central bank influences the expectations of economic agents' perspective of future monetary stance, which also affects the level of current exchange rate.

It is well documented that the signalling channel is frequently nonexistent or weak in developing countries, due to the fact that central banks in these countries lack the record of responsible macroeconomic management and are therefore at a disadvantage with respect to institutional and policy credibility. Therefore, investors may find it difficult to establish predictable and stable links between current and future monetary interventions Canales-Kriljenko, Guimaraes, & Karacadag (2003). The central focus of this study is to determine whether or not the official interventions on behalf of the Mexican central bank through the signalling channel in the foreign exchange market had an effect on the exchange rate expectations during the period of 2008 to 2010. This will shed light on the extent of Banxico's policy credibility, after a decade where numerous reforms to achieve this were made and during a period in which Banxico's capacity to influence investor expectations were put to the test. This could also promote an additional policy through which Mexican central bank can affect exchange rate expectations of investors and other market participants.

In the first section, the theoretical framework is presented where the theory behind the signalling channel is exposed. In the second section, an analysis of the main literature regarding the topic is presented. In section three, the mechanisms of intervention of the FEC are explained. In section four, the methodology that was employed is explained. Section five exposes the data that was used in the investigation. Section six presents the main econometric results along with their interpretation. Finally, section seven explains the main conclusions that were derived.

THEORETICAL FRAMEWORK

During the 15 years, following the Bretton Woods experience of the 1970´s, economists have used exchange rate theory to develop several standard monetary models that use the Cagan functional form of the demand of money and purchasing power parity conditions to formulate equations that estimate foreign exchange rate volatility. Models such as: the overshooting model of Rudiger Dornbusch which is based on differential speed of adjustment between the commodity and asset markets; the asset market variants of the monetary approach introduced by Jacob Frenkel and Michael Mussa: and the current account portfolio approach developed by Pentti Kouri were introduced during the flexible exchange rates and stabilization policy held in Sweden in the summer of 1975 to help understand the behavior of foreign exchange rates. All of these models have a unique perspective on the way exchange rates are determined, however they all share and emphasize on the importance of integration and efficiency of international asset markets to successfully understand and predict exchange rate volatility. Billson & Marston (1984)

There are different approaches to explain changes in the foreign exchange rates with each one taking into account a varied amount of variables. Even so, there is a consensus that the variables that determine the exchange rate are the difference between national and foreign values of monetary stock, real income and interest rates against that of a foreign country. These are known as the fundamentals and are considered in a wide array of models.

The modern asset market view introduced by these authors for exchange rates centers around the concept that exchange rates are relative asset prices that are strongly influenced not only by current events but also by future market speculations, therefore information and uncertainty have significant effects on exchange rate levels. The changes in exchange rates that occur over short periods such as a week of a month are normally volatile and unpredictable, this randomness is a characteristic that authors such as Mussa have linked to that of the prices of common stocks, making these models weak against modern random walk theory. Mussa (1981)

As a result of these empirical studies, there has been much debate however whether or not these standard monetary models can explain and significantly predict foreign exchange rates or even outperform a random walk model in the short term.

Evidence and empirical work of several authors suggests that these exchange rate models have not yet produced results that are sufficiently satisfactory for them to be considered strong enough to explain foreign exchange rate volatility, and commonly fail to outperform forecasting tests over a random walk model. Sarno and Taylor (2002, 136-137)

The three most common channels of influence that the central bank can use to intervene on the foreign exchange rate market and therefore reduce exchange rate volatility are; portfolio balance, microstructure and signalling. The portfolio balance channel is based on the restructuration of agent's foreign asset portfolio which is adjusted to rebalance the riskiness of the portfolio. The microstructure channel is based on the aggregation of end-user's pressure on the foreign exchange by demanding or offering their foreign assets. The expectation or signalling channel is a mechanism through which the central bank can have an effect on the exchange rate. The theory establishes that the exchange rate is defined not only by the present value of the fundamentals but it also takes into account the market's expectation of their future value. The interventions are used as a new set of information that signals future actions of the central bank. Therefore, the updated expectations of the agents are reflected in the level of the exchange rate. It is assumed that the central bank has privilege information. The logic behind this is that through the intervention the central bank is expressing the interior information about future actions. Even if the expectations of monetary policy are not fulfilled, the present value of the exchange rate might change. For example, when the authorities intervene to maintain the purchasing power of a currency, it is likely that the monetary measures in the future will not contradict this position. International reserves are limited and expensive so it is not rational to have contradictory policies.

Given that the signalling channel is based on the expectations of the market, it is necessary that the central bank is able to influence these expectations. Credibility of the monetary authority is a key feature to provoke the right signal; if the actions are not credible, then the expectations will not shift and this would represent a cost for the central bank with no benefit.

Therefore there are incentives for intervention to be public and send a clear message to the market participants. Kenen (1988, 52) quoted by Sarno and Taylor (2001, 844) states that the rules for exchange rate management should be as transparent as possible. That is to maintain credibility, not by studied ambiguity, which breeds disagreement and distrust. The problem that developing countries may have, as pointed by Canales-Kriljenko, *et al.* (2003, 7), is that their central banks lack the record of prudent macroeconomic management that underpins the strong credibility of monetary authorities in advanced economies. As well, on going structural shifts in many developing countries make it difficult to establish predictable and stable links between real and financial variables.

LITERATURE REVIEW

Literature related to the effectiveness of the exchange market has been growing rapidly, especially after the publication of intervention episodes by the central banks of the mayor economies (mainly the G-3 countries). The literature shows different results depending on the methodology and the data set used. The perspective of whether intervention has been effective has shifted over the years. Recent studies have provided arguments to support intervention to affect foreign exchange markets, but there is no clear conclusion that it can be used as an independent policy from the monetary and fiscal policies. Truman (2003) presents a summary of the perspective of academics and policymakers about intervention throughout the years.

Edison (1993) and Sarno and Taylor (2001) make an excellent survey of the literature related to the signaling channel.2 There is no one standard methodology that has been followed throughout the years but most of the studies finds that sterilized intervention has had a significant effect through the signaling channel. There are two main approaches used in the research surveyed by Sarno and Taylor: the first approach uses the context of the portfolio-balance model to determine the impact of intervention on exchange rate expectations, the second one estimate if the intervention actually signals a future monetary policy. Some of the most significant studies to review the first approach are Humpage (1989), Dominguez (1990), Obstfeld (1990) and Dominguez and Frankel (1993). The first two cannot precisely isolate the signaling hypothesis while the third one uses survey data on forecasts of exchange rate to represent expectations.

Dominguez (1990) examines the motivations of the central bank and the responses of the market to the interventions over the period of 1985 through 1987. Industrial country monetary authorities did both coordinated and uncoordinated large-scale intervention in the foreign exchange market during this period. Previous studies of the period presented evidence to neglect a significant effect of the portfolio effect. Therefore, Dominguez analyses the effect of intervention through the signaling channel. The signaling hypothesis is rested in two assumptions: the central bank is believed to have inside information about future monetary policy and the central bank has incentives to reveal the information truthfully. The study focuses on the intervention of the United State's Fed, Deutsche Bundesbank and the Bank of Japan during five episodes of coordinated intervention. The estimated regression uses the risk premium as the dependent variable, assuming rational expectations. The coefficient of intervention provides information of both the signaling and portfolio channels.

The standard portfolio channel methodology uses cumulated intervention as a variable, using the actual intervention Dominguez argues that this gives information on the effectiveness of the expectation channel. Dominguez finds evidence that intervention through the signaling channel was effective and correctly signed for coordinated and uncoordinated interventions during the first two episodes; the remaining three episodes were either not significant or presented the wrong sign. This is a useful framework since

it does not require a broad number of variables to regress the estimations but it is limited since it can't precisely disentangle the portfolio and signaling channels.

Further studies such as Dominguez and Frankel (1993) use a different methodology to solve the problem of disentanglement of the channels mentioned before. For this estimation the authors use the investor's formation of expectations of future spot rate. According to Edison (1993), this framework is more appropriate for testing the signaling channel because the expectations equation includes all the variables that may enter the reduced form for exchange rate, not only intervention as used before. Since the expectations are not available in a daily basis, the approach changes to a weekly and bi-weekly approach. The results show evidence of both portfolio and signaling channels. Even when this methodology is more precise and separates both channels, it is still limited since the information is not daily as the other studies such as Humpage (1989) and Dominguez (1990). Interventions closer to the day of the survey to the investors might have a higher impact than those that are far apart from them. In the specific case of Mexico, there is no public survey that estimates the expectations of the investors or experts to a daily, weekly or bi-weekly basis. The central bank publishes a monthly survey were the opinion of experts related to the spot exchange rate is expressed.

Even so, the expectations may vary widely throughout the month making the days in which the survey was implemented an important factor that might be biased. Given this situation this methodology, even when it might be more adequate, will not be used to estimate the impact of intervention through the signaling channel.

Some of the literature related to intervention signaling future monetary stance are: Dominguez (1992), Klein and Rosengren (1991 a, b), Lewis (1995) and Bonser-Neal, Roley and Sellon (1998). Using data from the United States and Germany, Dominguez (1992) concludes that intervention conveys information about expectations of future monetary supply and intervention tends to influence these expectations. Similar results where found on previous studies by Dominguez (1987) quoted in Sarno and Taylor (2001): money supply surprises are related to intervention in periods of high credibility of the central bank and that in such periods when intervention was conducted the monetary authorities are able to influence exchange rate changes. The methodology uses two regressions, the first relates intervention with unforcasted (publicly available forecast against actual money supply) changes in money supply and the second one estimates the risk premium. Klein and Rosengren (1991a) find that intervention did not have a significant effect in the monetary policy. After the Plaza Agreement intervention had a significant effect on the exchange rate but not subsequently, this is explained by the authors by arguing that the market participants learnt that intervention was not followed by a consistent change in the monetary policy. In a following study Klein and Rosengren (1991b) show that the effect of intervention declines as the time between the intervention and monetary policy announcement is made. This might have an effect on the present investigation due to the announcements of monetary policy are programmed periodically and by then the participants in the auctions knew the mechanisms through which the interventions were going to take part. In a similar analysis, since the actual interventions might not have an impact through the signaling channel if the expectations are not

modified by the actual interventions but by the announcement on changes in the mechanisms. Therefore, intention might have a greater effect when both the monetary and intervention policy announcements are done simultaneously or close in time to each other.

Finally, Lewis (1995) present evidence through a Granger-causality test to support the hypothesis that intervention and monetary variables such as M1 and monetary base are significantly related. Bonser-Neal *et al*. (1998) find similar conclusions of Lewis by providing evidence of signaling and learning against the wind in the interventions conducted by the U.S.

Since the developed countries have stopped intervening on the market since the 1990's (except for Japan that has had more recent episodes of intervention) more recent work has focused on developing countries. Disyatat and Galati (2005) argue that the signaling channel might be less effective in emerging markets since the central banks lack the history of institutional policy credibility. Therefore, monetary authorities have to intervene with bigger sums than industrialized countries to "buy credibility". Canales-Kriljenko, Guimarães, and Karacadag (2003) add that due to the trends of these countries on their financial structure it is difficult to establish a relationship between real and financial variables, therefore the link between intervention and future monetary policies is not clear.

MECHANISMS OF INTERVENTION IN MEXICO

Throughout the years the FEC has implemented several mechanisms of intervention to fulfill different objectives. After the crisis in 1995 financial stability was a fundamental requirement to allow economic growth therefore a mechanism to increase the international reserves was implemented in 1996 and ended in 2001. Alongside an additional mechanism was employed to reduce volatility but was executed in only 14 occasions during the 4 years it was active. In 2003 a new method was device to reduce the accumulation of international reserves without having an impact on the exchange rate market; this mechanism ended in July of 2008.

Guimarães and Karacadag (2004) analyze the impact of the interventions on the level and volatility of the exchange rate through these last mechanisms. The authors conclude that intervention seems to have a non-negligible effect on exchange rates wish dollar *sales* appreciating the peso but the purchases, which were the bulk of intervention, did nor appear to have had a statistically significant impact on the value of the peso. This is consistent with the authorities' objectives of intervening without affecting the free floating of the peso. The conclusions have a direct impact on the present study since the objectives of the FEC are a central point of the effectiveness of the interventions. The different mechanisms implemented intend to solve distinct situations therefore each one of the mechanisms implemented during the period covered in the present study should be analyzed independently. During the period of October 2008 until April 2010 the FEC

implemented four mechanisms of intervention to auction dollars in the foreign exchange market.

The objective of the Mexican Central Bank (Banxico) was primarily to reduce volatility and provide liquidity during the period of the 2008 financial crisis. This intervention signified a new system compared to past policies. Over the 18 months of study, a series of mechanisms were implemented over time, each with particular purposes and amounts, these interventions were known as; extraordinary interventions, auction of dollars without a minimum price, auction of dollars with a minimum price and a swap line of credit with the US Federal Reserve Bank.

Extraordinary Interventions were a type of mechanism instrumented by the Federal Exchange Commission (FEC) as a result of high uncertainty conditions and low of liquidity in the foreign exchange market. The first intervention and most considerable in overall quantity took place on October 8th of 2008 with the auction of 998 million US dollars at a weighted exchange rate of 12.0159 Mexican Pesos per USD dollar followed by a second extraordinary intervention the following day of 1.5 billion USD dollars at a weighted exchange rate of 12.0794 Mexican Pesos per dollar. Interventions of this type would only occur 3 more times over the total period of study.

4 months after the first intervention took place, on March 5th of 2009, the FEC, with the purpose of providing ordered conditions in the exchange market implemented the auction of dollars without a minimum price. This mechanism guaranteed that a significant part of the international reserves were sold in the exchange rate market. This included a daily auction of 100 million US dollars through an auction mechanism instrumented on behalf of Banxico. Additional to this, Banxico would continue to auction dollars at a minimum exchange rate of 2 percent above the exchange rate of the immediate day before. This mechanism would be known as auction of dollars with minimum price and would start of 400 million US dollars per day and later be reduced to 300 million.

Finally on April 3rd of 2009, Banxico announced that it would activate a temporary mechanism for the exchange of currency known as a "swap line of credit" with the Federal Reserve of the United States. This mechanism was publicly released through a press statement the 29th of October of 2008 and was active until October 30th of 2009. The main purpose of the swap line of credit was to provide financing to participants of the private sector that faced pressures to obtain resources of US dollars. Table 1 presents a summary of the interventions of the FEC during this period divided by the type of mechanism.

Table 1: Mexico's Central Bank Foreign Exchange Intervention
(October 2008-February 2010)

Dates	Mechanism	Duration of Mechanism (Days)	Amount of Intervention (Days)	Frequency	Amount Sold (US$, millions)
10/08/2008 – 10/23/2008	Extraordinary Auctions*	12	5	Ad-hoc	11,000
10/09/2008 – 04/12/2010	Auction of dollars with a minimum price	374	28	Daily	8,339
04/09/2009 – 09/30/2009	Auction of dollars without minimum price	143	143	Daily	10,250
10/10/2008 – 10/30/2009	Swap Line with The Fed and credit auctions	226	1	Ad-hoc	3,221

*This mechanism was implemented discretionally, so the dates of its implementation are merely the period in which the FEC intervened from beginning to end.
Source: Elaborated by the authors with information from Banxico.

METHODOLOGY

The methodology that will be employed is similar to that used by Dominguez and Frankel (1990). The authors construct and estimate an equation of expectations formation, using the investor's forecast of the expected future spot rate as the dependent variable. The authors construct expectations through the use of surveys. The specification that they employ allows for adaptive expectations, extrapolative expectations, central bank interventions, and a news variable. The econometric equation that they construct is the following:

$$(1)\ S_{t+k}^e - S_t = \alpha_0 + \alpha_1\left(S_{t-j} - S_t\right) + \alpha_2(S_{t-1+k}^e - S_t) + \alpha_3(Int_t) + \alpha_4(News_t) + \varepsilon_t$$

where:

S_{t+k}^e: Log of the survey prediction of the spot rate in the period $t+k$

S_t: Log of the spot rate in period t

S_{t-j}: Log of the lagged spot rate until period j, where j represents the time of the last survey

S^e_{t-1+k}: Log of the lagged survey prediction of the spot rate

The dependent variable represents the difference between the expected exchange rate that an investor in period t has for the future exchange rate in period t+k. It is a measure of the expectations of the market participants ex ante. k is the number of periods between the present period t and the period for when the investor has a particular expectation. There is a serious limitation in this respect for the case of Mexico since the authors do not know of the existence of a survey which includes the forecast of the exchange rate made by experts or participants. There is one survey with similar information presented by Banxico but it contains a monthly forecast of the exchange rate at the end of the year. This would present a systematic bias since the surveys closer to December would convey much more information than those of the beginning of the year. Given this limitation it is necessary to use a variable that measures the market's expectations of the peso/dollar exchange rate in the future.

Dominguez and Frankel (1990) argue that measurements ex post are particularly bad measure of what investors expected ex ante which actually reflect the expectations. Therefore it is necessary to use a variable that shows the expectations of the exchange rate ex ante that conveys the information available to the market at the time that the forecast is made. Hakkio (1980) states that the forward exchange rate provides an "optimal" forecast for the future spot exchange rate. Therefore, in this study the forward for the peso against the dollar exchange rate for one month, three months and one year ahead will be used instead of market surveys. Therefore, the regression equation that will be estimated is:

$$(2)\ F_{t+k} - S_t = \alpha_1(S_{t-1} - S_t) + \alpha_2(F_{t+k-1} - S_t) + \alpha_3(Int_{t-2}) + \alpha_4(News_t) + \varepsilon_t$$

where:
F_{t+k}: Log of the forward exchange rate of period $t+k$

S_t: Log of the spot rate in period t

S_{t-1}: Log of the lagged spot rate of period 1

F_{t+k-1}: Log of the forward exchange rate in period $t+k-1$

Int_{t-2}: Intervention of Banxico in period $t-2$ measured in dollars

$News_t$: Variable which captures reports of Banxico´s exchange rate policy news. 1 represents news in favor of the peso, -1 news against the peso, and 0 represents no relevant news.

ε_t: Error term

In this model, the constant will be excluded. The reason is that it is possible to imagine all the independent variables assuming the value zero simultaneously; in which case it follows that the dependent variable will also be zero. In such cases it is acceptable to exclude the constant in the regression.

The econometric model was specified by using two days lagged intervention, as specified by Domaç and Mendoza (2004). As Werner (1987) specifies, the variable intervention purchases cannot be exogenous since it is correlated with the error term. The problem is addressed by using the two period lag of the variable as instrumental variable. The model thus uses the two lagged in the intervention.

We now proceed to analyze the coefficients of each of the explanatory variables.

α_1: Coefficient that measures the effect that the difference between the current and lagged spot rate has on investor expectations. It measures the extent to which past exchange rate changes influence current exchange rate expectations; a measure of *extrapolative expectations*. $\alpha_1 > 0$ is expected; a past appreciation leads to the expectation of an appreciation in the future.

α_2: Coefficient that measures difference between the lagged future exchange rate and the current spot rate. It measures the degree to which past expectation errors $(F_{t+k-1} - S_t)$ explain current expectations $(F_{t+k} - S_t)$, a measure *of adaptive expectations*. $\alpha_2 < 0$ is expected; the expectation error of the last period has an opposite effect on the expectations for tomorrow. For example, an expectation error in which the currency depreciated more than was expected will cause the current depreciation error to be smaller.

α_3: Measures the intervention by the FEC at the end of the day in period t, before the survey measures. The intervention is measured through the amount of dollars sold through the auctions in the foreign exchange market. $\alpha_3 < 0$ is expected; if the central bank sells dollars in the foreign exchange market, we expect the peso/dollar exchange rate to decrease.

α_4: Captures the effect that Banxico's exchange rate policy news has on investor expectations. $\alpha_4 < 0$ is expected; therefore Central Bank publication news in favor of the Mexican are expected to make the peso stronger (i.e. appreciate the Mexican peso over the US Dollar).

Since the present spot rate is a determinant of the forward value, there is a strong possibility that the measurement errors of these variables are correlated. In this case, serial correlation can represent a serious obstacle to the obtainment of reliable statistical estimates. The problem of serial correlation can be corrected by using a variety of ARMA models, depending on the amount of autoregressive or moving average coefficients which turn out to be significant. After this, a Breusch-Pagan LM test must be employed to assure that no more serial correlation is present. This specific test is used since the Durbin Watson (DW) statistic cannot be employed when lagged regressors are present.

DATA

The data includes the period from the 9th of September 2008 until the 9th of April 2010, which is the total period for which the FEC decided to intervene in the foreign exchange market. The intervention amounts are available to the public by Banxico on the online statistics section of "Operations of Banco de México in the exchange market" in www.banxico.org.mx. The four mechanisms (extraordinary, minimum price, no minimum price and swap line interventions) were included as part of the total intervention, adding the value for each day as a total amount measured in US dollars. The spot exchange rate expressed in Mexican pesos per US dollars is available in the statistics section at Banxico's website. The news variable was also elaborated incorporating related news published at Banxico's webpage under Communication Statements section of Monetary Policy Intervention. Where news variable takes a value of 1 on a day where public statements where published in favor of the Mexican Peso, -1 for public statements against the Mexican Peso and 0 if there was no statement on that particular day. The information regarding the forward exchange rate within the peso and the dollar for the three periods was obtained from the Financial Times' historical data. Where there was no available information for the forward exchange rate, the value for given day was estimated through an average of the previous and next day. For all variables, the total amount of collected observations is of 375 days. Table 2 presents descriptive statistics of the variables used in the estimations.

Table 2: Descriptive Statistics

	Mean	**Std. Dev.**	**Skewness**	**Kurtosis**	**Stationarity**
Expectations 1 Month	0.00536	0.00471	1.45603	52.5420	Stationary
Expectations 3 Months	0.05454	0.00973	0.47400	8.22427	Stationary
Expectations 1 Year	0.01480	0.00630	-0.31561	19.9596	Stationary
Adaptive Expectations 1 Month	-2.58219	0.04358	-1.05626	4.44557	Stationary
Adaptive Expectations 3 Months	-2.53301	0.04144	-1.10431	4.42648	Stationary
Adaptive Expectations 1 Year	-2.57280	0.04258	-1.109028	4.55588	Stationary
Extrapolative Expectations	0.000273	0.264202	7.858535	7.858535	Stationary
Total Interventions	87.49333	402.9383	12.12294	174.3010	Stationary

Elaborated by the authors with information as specified above.
The stationarity condition was evaluated using the Dickey-Fuller Unit Root Test with significance levels of 1%, 5% and 10%.

The expectation means of 3 months and 1 year expectations is greater than that of 1 month. This implies that the difference between the forward and spot exchange rate was smaller (i.e. investors are more precise with regard to expectations) for smaller periods of time during the financial crisis. This comes as a surprise, since one typically expects the exchange rate to be more unpredictable in the short run than in the long run. Analyzing the skewness data, it is clear that the expectations for 1 month is positively skewed (i.e. there is more positive data). The unusually high kurtosis means that more of the variance is the result of infrequent extreme deviations of short run expectations, which is expected to the short term volatility of exchange rate expectations. Interestingly, these descriptive statistics imply that 1 month exchange rate expectations are volatile, yet they are more precise than longer term exchange rate expectations.

Most importantly, a unit root test to check for stationarity was carried out for each of the variables. The null hypothesis of the presence of a unit root was rejected in each case, implying stationarity for each variable. This implies that the means and variances of the variables are constant over time, and the least squares estimates will be consistent, unbiased, and of least variance.

RESULTS

Below are the results of the estimated regression equations for the different mechanisms of intervention that the FEC used: minimum price, without minimum price, extraordinary interventions. Since the swap line with the Fed and credit auctions mechanism was only used once during the whole period analyzed there is no estimated regression that separates this mechanism. The sums of these interventions through the four mechanisms (including the swap mechanism) are also considered as a separate variable, to determine the combined effect on exchange rate expectations. For each form of intervention mechanism 3 different periods of time are analyzed: 1 month, 3 month, and 1 year. A total of 12 regression equations were estimated, 3 for each of the 4 interventions analyzed. Each table has a column which specifies the econometric model that was used to correct for serial correlation in each equation, since in all equations the presence of serial correlation was substantial. Both ARMA (Autoregressive Moving Average Model) and AR (Autoregressive Model) were used to correct for this serial correlation. Before the statistical estimates were accepted, a Breusch-Pagan LM test was used to test for this serial correlation and ensure the robustness of the estimates.

Table 3: Regression Results for Expectations in 1 Month, 3 Months, and 1 Year for
Total Interventions
Estimation Technique: OLS
(Observations = 373)

$$(2)\ F_{t+k} - S_t = \alpha_1(S_{t-1} - S_t) + \alpha_2(F_{t+k-1} - S_t) + \alpha_3(Int_t) + \alpha_4(News_t) + \varepsilon_t$$

Dependent Variable	α_1	α_2	α_3	α_4	Econometric Model	Adjusted R^2
1 Month Expectations	0.0445** (0.0433)	-0.021* (0.00389)	-0.00062 (0.237)	-0.048* (0.0094)	AR (2)	0.28
3 Month Expectations	0.0402*** (0.0681)	-0.026*** (0.0745)	-0.00429 (0.20)	-0.04397 (0.1495)	ARMA (2,2)	0.59
1 Year Expectations	0.0460*** (0.0847)	-0.047** (0.0356)	-0.00463 (0.856)	-0.06456 (0.2581)	ARMA (2,2)	0.76

* Significant at 1%. ** Significant at 5%. *** Significant at 10%. P-values in
parenthesis.

All the variables of the regressions for the expectations of 1 month had different degrees
of significance. As was expected, a positive significant (at 5%) estimate of 0.0445 was
obtained from the extrapolative expectations coefficient, implying that past depreciations
of the peso led to future expected depreciations. Since this variable is in logarithms, a
past depreciation of 1% led to a future expected depreciation of 4.45%. As expected, a
negative significant estimate of -0.021 was obtained from the adaptive expectations
coefficient, implying that past errors in expectations lead to an improvement in current
expectations. That is, investors learned from their past mistakes. Specifically, if an
investor miscalculated the depreciation by 1%, then the expectation error decreased by
2.1%.

The more interesting finding in the signaling hypothesis is the coefficients
α_3 and α_4. For the overall effect, the results do not have statistical significance in any of
the 3 periods therefore this variable is not explicative for the total interventions and there
is no evidence for the signaling channel when analyzing the combined effect of all
interventions. As stated before, this is a reason why further analysis is required to
disentangle the mechanisms used by the FEC. Additionally; the news published at the
communication statements of Banxico had a non-negligible effect to reduce the
expectations of further depreciation in the 1 month horizon. This means that the estimate
of -0.048, with an expected negative sign, has the effect that any positive exchange rate
news that favored the peso decreased the expectation of further depreciation of the peso
by -4.8%.

Table 4: Regression Results for Expectations in 1 Month, 3 Months, and 1 Year for
Extraordinary Interventions
Estimation Technique: OLS
(Observations = 373)

$$(2)\ F_{t+k} - S_t = \alpha_1(S_{t-1} - S_t) + \alpha_2(F_{t+k-1} - S_t) + \alpha_3(Int_t) + \alpha_4(News_t) + \varepsilon_t$$

Dependent Variable	α_1	α_2	α_3	α_4	Econometric Model	Adjusted R^2
1 Month Expectations	0.0272** (0.01960)	-0.0089 (0.25)	-0.00185 (0.7665)	-0.0201 (0.2979)	ARMA (2,2)	0.26
3 Month Expectations	0.0374*** (0.0875)	-0.015 (0.17)	-0.0012 (0.1817)	-0.0282 (0.2873)	ARMA (2,2)	0.59
1 Year Expectations	0.0560** (0.028)	-0.049** (0.026)	-0.0019*** (0.066)	-0.066 (0.2142)	ARMA (2,2)	0.77

*Significant at 1%. ** Significant at 5%. *** Significant at 10%. P-values in parenthesis.

The table above summarizes the estimates for the extraordinary interventions. For the expectations of 1 month, the only significant coefficient was that of extrapolative expectations, indicating a positive significant influence of past exchange rate changes on the current exchange rate. Neither the intervention variable nor the news variable had a significant effect. The same results were found for the 3 month expectations, although extrapolative expectations were less significant in this case.

For 1 year expectations, both extrapolative and adaptive expectations were significant. Most importantly, the intervention variable was significant and had a negative effect on exchange rate expectations. An extraordinary intervention of US$100 million reduced the 1 year expectation of the peso/dollar exchange rate by 0.19%. This mechanism is different from the auctions with minimum price and without minimum price for several reasons. This is an ad-hoc measured implemented only during the first days of the crisis while two of the other mechanisms were daily auctions which the market participants decided when to buy dollars from the central bank. Therefore, market participants did not expect these interventions so every time the FEC decided to intervene a new information set was available, making a change in the expectations about future monetary stance. The theoretical framework and literature review mainly analyze interventions similar to the extraordinary auction mechanism making this the most important of all the mechanisms applied by the FEC.

Extraordinary interventions had an effect on the exchange rate expectation 1 year from now, but not 1 month or 3 months from now. A possible explanation is that in the short and medium run, exchange rate expectations were determined more by past trends and other short term variable than by any action FEC took, as suggested by the significance of extrapolative expectations in these cases. This can be seen in the increasing explicative power of the model as the period increases from 1 month to 1 year. However, FEC´s intervention did affect investor´s long term (i.e. 1 year) perception of the future trend of central bank actions, affecting exchange rate expectation 1 year from now. This was

positive in the sense that the FEC's actions did signal the central bank's long run intervention stance.

Table 5: Regression Results for Expectations in 1 Month, 3 Months, and 1 Year for
Minimum Price Interventions
Estimation Technique: OLS
(Observations = 373)

$$(2)\ F_{t+k} - S_t = \alpha_1(S_{t-1} - S_t) + \alpha_2(F_{t+k-1} - S_t) + \alpha_3(Int_t) + \alpha_4(News_t) + \varepsilon_t$$

Dependent Variable	α_1	α_2	α_3	α_4	Econometric Model	Adjusted R^2
1 Month Expectations	0.0108 (0.6281)	-0.025* (0.001)	-0.00185 (0.7665)	-0.06* (0.0026)	AR (2,2)	0.15
3 Month Expectations	0.038*** (0.0898)	-0.022*** (0.0741)	0.00138 (0.5954)	-0.04 (0.1393)	ARMA (2,1)	0.58
1 Year Expectations	0.041** (0.1358)	-0.052** (0.016)	0.0031*** (0.2890)	-0.07 (0.1476)	ARMA (2,2)	0.76

*Significant at 1%. ** Significant at 5%. *** Significant at 10%. P-values in parenthesis.

The table above summarizes the results for minimum price interventions. For 1 month expectations, the adaptive and news coefficient's were significant and had the expected sign. Investors and market participants are able to learn from the mistakes of their past exchange rate predictions, and news that supported the peso/dollar exchange rate appreciated the peso. For the 3 month expectations, both extrapolative and adaptive expectations were significant at 10%. The intervention coefficient was not significant in either of these two cases. For 1 year expectations, both extrapolative and adaptive expectations were significant at 5%, and the intervention coefficient was significant at 10%.

For the auctions with minimum price and without minimum price the coefficient of intervention has the opposite expected sign. This could be explained by the way the mechanisms are implemented. Since the auctions are made daily the participants already know the auctions amount and the only determinant of entering the auction would be that the expectations or the present spot rate would be higher than the spot rate from the previous day. In this situation news about changes in the mechanisms actually convey information about the central bank's perspective about the economy and uncertainty in the market. Therefore, this would mean that intervention does not affect the expectations but the other way around. To prove this point a Granger causality test was conducted and concluded that both auctions with minimum price affect expectations and the other way around, but the causality was higher from the expectations to the interventions. Therefore, the coefficient is positive since when the auctions are made effective there is an increase in the expectations of future depreciation of the peso.

Most importantly, the news variable takes into account that changes in the mechanisms of intervention as a positive sign of the economy because it is possible to auction fewer amounts of dollars and still keep the interventions' objectives. The actual change in the mechanism might have a higher impact on the expectations since it is a new set of information. The news coefficient is significant in the 1 month horizon meaning that for every US$100 million the expectations of depreciation of the peso decreased by 6%.

Table 6: Regression Results for Expectations in 1 Month, 3 Months, and 1 Year for Auctions Without Minimum Price
Estimation Technique: OLS
(Observations = 373)

$$(2)\ F_{t+k} - S_t = \alpha_1(S_{t-1} - S_t) + \alpha_2(F_{t+k-1} - S_t) + \alpha_3(Int_t) + \alpha_4(News_t) + \varepsilon_t$$

Dependent Variable	α_1	α_2	α_3	α_4	Econometric Model	Adjusted R^2
1 Month Expectations	0.0322 (0.473)	-0.019 (0.258)	0.00316*** (0.0687)	-0.047 (0.275)	AR (2,2)	0.05
3 Month Expectations	0.0209 (0.6326)	-0.026*** (0.0872)	0.0052* (0.0006)	-0.058 (0.1364)	AR(3)	0.08
1 Year Expectations	0.036 (0.4035)	-0.029*** (0.053)	0.0051* (0.0036)	-0.066*** (0.0854)	AR(1)	0.76

*Significant at 1%. ** Significant at 5%. *** Significant at 10%. P-values in parenthesis.

For the 1 month expectations, only the intervention coefficient was significant. For the 3 month expectations, both the adaptive coefficient was significant at 10% and the intervention coefficient was significant at 5%. For the 1 year expectations, both the adaptive expectations and news coefficients were significant at 10% and had the correct sign. News in support of the peso/dollar exchange rate appreciated (i.e. made stronger) the expectation of the exchange rate 1 year from now. The intervention coefficient was significant at 5%.

As opposed to the minimum price auction, the positive sign of the intervention coefficient cannot be explained by causality from the expectations to the actual interventions. This sign is not supported by the theoretical framework, it is not possible to adequately interpret the effect of this intervention. The coefficient for news at the 1 year horizon is significant; a similar interpretation is possible for this mechanism. Changes in the mechanisms convey information about future monetary policy as well as the expectations of the authorities' perspective on the economy and the exchange rate market.

CONCLUSIONS

There appear to be statistically significant effects through the expectations channel in Mexico. The quantitative magnitudes of the effects vary depending on the mechanisms

employed and the horizon considered. The mechanism that was the most successful in signalling the future stance of monetary policy was found to be the extraordinary interventions, which is the most theoretically sound mechanism for which the intervention period effectively reduced the expectations of future depreciations of the Mexican peso. We discover that in Mexico extraordinary interventions of US$100 million on behalf of the FEC reduced the 1 year expectation of the peso/dollar exchange rate by 0.19%. This implies that when the central bank in Mexico wishes to signal its future monetary policy, it should make more use of extraordinary interventions. If Banxico wishes to signal in the short run, it would need to increase the magnitude of the interventions.

For the specific case of extraordinary interventions, the actual intervention had a more significant impact on expectations, but for the other mechanisms were the amount and dates were pre-established, the actual news about changes of these mechanisms seem to be more important than the actual quantities. However, the actual interventions for these mechanisms had an opposite effect on exchange rate expectations, which cannot be theoretically explained by the employed model.

In further studies, it will be interesting to do a probability test to determine if actually excessive exchange rate volatility decreased the probability of intervention through the mechanisms of daily intervention.

It is important to mention that during the financial crisis, other factors that are not considered in the model could have had an impact on exchange rate expectations, such as interest rates, inflation rates, etc. Further studies could also consider such variables and provide a more comprehensive model to explain these expectations.

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