An Empirical Devaluation Model of the Mexican Peso[1]

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Abstract

In 1986, Blanco and Garber derived an empirical model to predict currency devaluations in fixed exchange rate regimes primarily due to speculative attacks. Focusing on Mexico, the model dealt with the exchange rate collapses from 1973 to 1982. According to the paper, devaluations would occur when the underlying floating exchange rate exceeded the current fixed rate and foreign exchange reserves reached a particular low determined by the government. The probability of devaluation provided by the model spiked significantly when actual devaluation occurred. However, this method has yet to be applied to the more recent devaluations that have occurred from 1986 to 1994 when the Mexican government switched from a crawling peg to a floating rate regime. In conducting this model on the more recent devaluations during this period, we achieved mixed results; however, these results seem to suggest that the 1994 devaluation was not primarily due to weak economic fundamentals that the model measures.

Introduction

Previous economic literature showed that speculative attacks leading to devaluation could be predicted by looking at investor and government rational behavior. To establish a fixed exchange rate regime, the government must keep foreign currency reserves in order to match any short-term foreign currency liabilities. Likewise, credibility is a necessity in deterring speculators from entering one's currency market. However, if there is tremendous volatility, especially in the form of short-term capital outflows, the central bank must maintain the fixed rate by running down its foreign reserves. When this volatility is accompanied by speculative pressure, the central bank must either devalue its currency, raise interest rates or do both to reduce the downward pressure on its foreign reserves. Because other adverse effects accompany a rise in interest rates, especially in developing countries, devaluation often times occurs.

With the continual regime changes in foreign exchange, Mexico has been more prone to speculative attacks, as the government has been unable to instill the credibility needed to maintain a fixed rate regime. Blanco and Garber provided the first empirical model to predict these devaluations in Mexico and to how big these devaluations would be from 1973 to 1982. Since then, the Mexican peso has experienced several major devaluations, particularly in 1987, and 1994. Mexico experimented with a variety of different fixed-but-adjustable regimes, as well as, floating the peso for the final quarter of 1987.

We wish to examine whether Blanco and Garber's method still holds true in predicting the timing and magnitude of these more recent devaluations. Similar time series are created akin to those in the original model, estimating the probability of devaluation and the expected exchange rate in the next period when these devaluations occur. However, unlike the previous paper, we wish to provide more intuitive reasoning behind the workings of this model so that we can better understand its successes and shortcomings.

The Model

First, we must assume that the Mexican fixed exchange rate policy is not the primary goal of the government. This assumption can be verified by the recurrent devaluations that Mexico has experienced during its fixed exchange rate regime. The central bank maintains this rate through its domestic credit since the fixed rate is a nominal price. Thus, when deciding between paying off the federal deficit and maintaining the current exchange rate, the government will always choose to devalue its rate.

The model is built primarily off the money market model, where B is the intercept in the model, Ω is the coefficient for the logarithm of real GDP, and α is the coefficient from the three-month Certificados de la Tesorería de la Federación (CETES). w_t is the stochastic disturbance in this equation.[3] Intuitively, because w_t is a disturbance term, one can view it as any external shock to the money demand at any given period. Furthermore, Blanco and Garber incorporate the purchasing power parity and interest rate parity equations to show how the exchange rates are affected by these variables.

In a fixed exchange rate system, the central bank pins the exchange rate by selling off and buying foreign reserves as needed. Devaluation occurs when these reserves are deplenished and reach a certain critical level, $\underline{R}$. This value is simply an arbitrary lower bound on reserves before the central bank deems it necessary to devalue so as to relieve speculative pressure on the domestic economy. Theoretically an upper bound could be put in place as a critical revaluation level, but such events rarely occur in a fixed exchange rate regime and are not dealt with in this paper. When the critical reserve level is attained, the central bank will establish a new fixed rate.

The newly established fixed exchange rate must be greater than the old fixed rate for the devaluation to have any viability. If new fixed rate were to be less than the old fixed rate, this event would be considered a revaluation. Similarly, with reserves under

[3] All data was obtained from the DataStream database at the Fuqua School of Business at Duke University and cross checked with Banco de México.

the critical level, revaluing so would only worsen excess money supply. As a result, speculators would put even more pressure on the central bank, despite foreign reserves already reaching the critical level. Blanco and Garber describe the new fixed rate as a background exchange rate that only becomes visible at devaluation. However, this rate must always be viable and therefore must exceed the old rate when reserves reach the critical level. At this point, a speculative attack occurs forcing the central bank to sell foreign reserves and forcing devaluation.

Blanco and Garber also argue that the newly established fixed rate must be greater than the underlying floating rate, the exchange rate that would occur if the currency were to float, to be viable. The difference between the two rates represents a buffer, giving the central bank relief from any immediate speculative attack. If the two rates were to be the same or if the underlying floating rate were greater than the current fixed rate, reserves would be at or lower than the critical level. Had the central bank adopted a pure floating exchange rate regime, foreign reserves would remain at the critical level permanently, as the bank would have no need to deal with the exchange rate. This infers that when devaluation occurs, the underlying floating rate represents the exchange rate where the critical level of reserves has been reached. If the central bank were to devalue rather than convert to a floating exchange rate, reserves would be under or at the critical level, which is simply not sustainable.

By substituting the purchasing power parity and interest rate parity conditions into the money market clearing condition, Blanco and Garber derived under a flexible exchange rate an equation that describes the logarithm of the speculative supply of money, h_t. The sum of the domestic credit and the value of foreign reserves in domestic currency represents the government's supply of money and when this supply is under pressure devaluation can occur. The money supply does not, however, indicate alone if there is going to be a devaluation problem. Foreign exchange reserves are simply sold off or bought on demand. If the domestic credit increases in a certain period, the money supply remains unchanged because reserves will fall by the same amount. This remains true because the transaction demand for money is exogenous from the money supply.

While the speculative supply of money is different after a floating rate is adopted during a fixed exchange rate regime, these differences are unobservable, and therefore, are assumed to be negligible. This equation for the speculative supply of money is a stochastic process and is assumed to be autoregressive as well as independent of the exchange rate.[4] θ_1 describes the intercept in this autoregressive process, θ_2 is the coefficient and v_t is white noise that is distributed normally.

Taking the difference between this autoregressive process and the speculative money supply equation, the flexible exchange rate can be solved for. In this equation, μ is the coefficient on the speculative supply of money. A central bank would be expected to optimize the new fixed exchange rate according to its policy priorities. However, this model assumes that this is a stationary environment allowing the government to rely on the current variables. This assumption allows us to create a simple linear function that describes the new fixed rate as the sum of the underlying fixed rate and a buffer term δv_t, where δ is greater than zero. When this parameter is less than zero, the underlying floating exchange rate is less than the current fixed rate. Therefore, reserves are below or at the critical level because there still will be an excess demand for money.

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[4] The h_t process could have been specified as a higher-order autoregressive process, however, for simplicity, we analyzed only the AR(1) process.

From this model, we can create a probability of devaluation at time t + 1. This probability function can be rearranged such that we can create such a function F, with a standard deviation of _, which allows us to predict future exchange rates based on probability of occurrence as well as the current fixed rate and expected newly established rate that would accompany devaluation.

From this equation, the expected exchange rate for t+1 can be calculated. In effect, the model predicts that the devaluation probability, 1 – F, will peak in the period prior to devaluation. The expected exchange rate should also be comparable to the existing forward rate, or the synthetic forward rate based on current interest rates. Lastly, the expected exchange rate should also be similar to the new exchange rate the Mexican government devalues to.

Estimation Procedures

The data we used extended from the fourth quarter of 1985 to the fourth quarter of 1994. We used 1990 as the base year to develop values of p_t, the implicit price deflator of Mexico, as well as the GDP in real terms. We calculated p_t by taking the logarithm of the ratio of the current CPI and our base CPI. To perform this, we simply collected data on the CPI of Mexico, utilizing the first quarter of 1990 as the base year. We multiplied the current GDP and current exchange rate the implicit price deflator to derive values for the constant GDP and exchange rate, respectively. We then took the logarithms of both values to solve for y_t, the real GDP, and u_t, the real exchange rate.

For the domestic credit component, D_t , we summed the net financing by the Banco de Mexico to the government, as well as other banks and financial intermediaries.

The end-of-quarter monetary base was utilized for M. For i and i*, we used the 90 month CETES rate and the 3 month Treasury Bill rate, respectively.

First, we estimated values for the money demand parameters by performing a multivariable regression on our data. These parameters allowed us to solve for the w_t series. We performed an initial estimation on $\underline{R}$ and δ values to compute the h_t, series. However, in accounting for peso movements, the government used a crawling peg regime that slowly devalued over time, rather than a strictly fixed exchange rate. Likewise, it must be noted that during our sampling period, the Mexican government floated its currency during the fourth quarter of 1987. As a result we solved for separate value of θ_1 and θ_2 from the fourth quarter of 1985 to the third quarter of 1987, and the first quarter of 1988 to the fourth quarter of 1994, when the Mexican peso was permanently floated. These parameters will be distinguished by subscripts A and B. Overall we recorded thirty six observations, ten of which were in period A, and twenty six of which were in period B.

In the previous paper, the model compared the unconditional expected exchange rate to that of future or forward exchange rates. The three month future rates for the peso f_t can be used to help predict the expected exchange rate, Ee_{t+1}. However, in the time period that we are looking at, we could not use future rates as the Mexican peso future contract was inactive from the mid 1980s to the mid 1990s. As a result, we tried to estimate the $\underline{R}$ and δ to minimize deviation from the interest rate parity condition.

Through the sampling period, we initially assumed that $\underline{R}$, the minimum allowable reserve value, was constant. However, the instability and growth of the Mexican economy proves that this assumption is false. Blanco and Garber multiplied the minimum reserve limit by an index of U.S. import prices to correct this assumption. In the process, they accounted for the declining real value of the dollar, as well as the greater Mexican borrowing due to the excessive oil price changes during their sampling period. Alternatively, to account for this assumption, we solved for individual values of $\underline{R}$ that would help minimize the sum of squares in interest rate parity condition during each quarter. By doing so, we were able to adjust the h_t series regardless of what might have been occurring in the Mexican economy. After initial values for θ_1 and θ_2 were regressed for, we solved for δ to minimize the sum of squares on q_t, the error in the interest rate parity clearing condition. We continued this iteration until we could no longer shrink q_t and values for δ converged.

Results

Results for the money demand parameters are seen in Table 1. These values were

Table 1

Estimates for the Money Demand Parameters

Parameter	Estimate
B	-19.83013
	(4.026057)
Ω	4.195275825
	(0.685632754)
α	-0.11328
	(0.0778)
R^2	0.88499

Table 1 – Estimates for the money demand parameters. Parentheses indicate the standard error value for each of these values. There were thirty six observations in this regression.

consistent with the money demand relationship between these variables.

The final estimates for μ, δ, _, θ_1 and θ_2 are displayed in Table 2. We assumed that δ, the proportion by which a new fixed exchange rate would exceed the current fixed exchange rate, remained relatively constant as θ_2 was extremely close to one.

Table 2

Estimates for Future Exchange Rate Parameters

Parameter	**Estimate**
δ	1.661278
θ_{1A}	0.21892051 (0.064672146)
θ_{1B}	0.086049822 (0.055708426)
θ_{2A}	0.87743 (0.07866)
θ_{2B}	0.87 (0.07033)
μ_A	1.01408
μ_B	1.014947
_	0.136449
R^2_A	0.954
R^2_B	0.85956

Table 2 - Estimates for future exchange rate parameters. Parentheses indicate standard error terms. Subscripts A and B refer to periods prior to, and after the peso was temporarily floated, respectively.

This estimate shows that the expected exchange rate for the next quarter is expected to remain relatively constant, as in a fixed exchange rate environment would suggest. The values of θ_1 and θ_2 between the two different time periods were comparable, both properly defining the autoregressive h_t series. For computing the function F series, we utilized different values of μ depending on the corresponding θ_2 value, also designated by subscripts A and B, respectively.

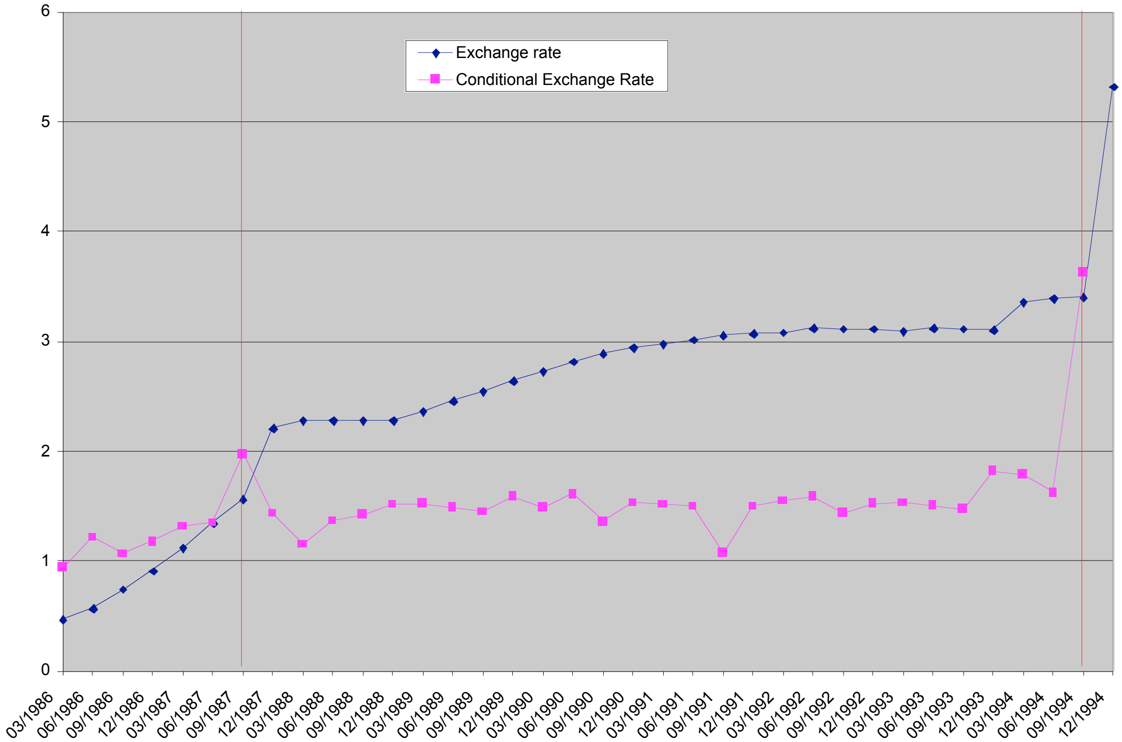

Figure 1 – Actual and conditional exchange rates based on devaluation. Vertical red lines indicate actual unexpected devaluation occurrences. The exchange rate is nominal, and the slow increase during times of currency stability is due to the crawling peg regime.

The exchange rate based on δ was comparable to the new exchange rate put in place after both major devaluations in the fourth quarter of 1987 and 1994. However, this was generally the case from the end of 1984 to the first devaluation in this sampling series. Comparatively though, the differential between the exchange rate upon devaluation and the current fixed exchange rate is much greater than the differential between these two exchange rates prior to the first devaluation. From 1987, the exchange rate remains below the fixed rate until the final devaluation in 1994, where it once again exceeded the current fixed rate.

The devaluation probabilities were less accurate in determining actual devaluation occurrences. Since the 1985 devaluation (prior to our series), the probability to devalue remained extremely high until the 1987 devaluation, where after the probability steadily declined even toward the devaluation in 1994. These early devaluation probability levels

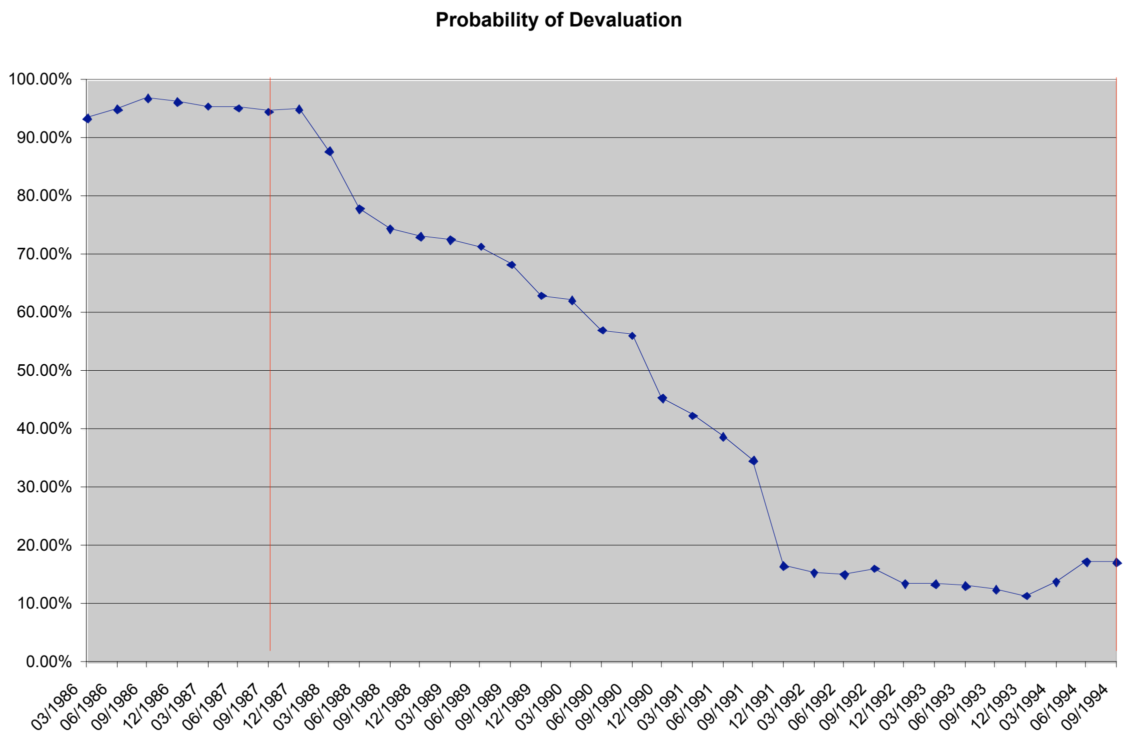

Figure 2 – Probability of Devaluation. Vertical red lines indicate devaluation occurrences.

are much higher than those seen in Blanco and Garber's study, and are not particularly useful in predicting actual devaluation occurrences.

The expected exchange rate conditional on devaluation preceding the 1987 devaluation trekked around 2.75, while the fixed exchange rate devalued from 1.56 to 2.2 pesos per dollar. However, in the devaluation of 1994, the expected exchange rate stood around 1.8, while the peso devalued from 3.4 to 5.325 before the Mexican government ultimately moved to a floating regime.

Discussion

The model's failure to predict the 1994 devaluation is not necessarily nor primarily due to the model itself. While the model proved to be successful in earlier time periods, the external factors and Mexican economic conditions were extremely different from the end of 1986 to the end of 1994. Unlike previous devaluations, there has been much debate on whether the cause of 1994 peso devaluation was due to economic fundamentals or political and external factors. The results derived from this model seem to suggest that the economic fundamentals were not at complete fault for the last major devaluation of the Mexican peso.

In the latter half of the 1980s, the Mexican government began initiating economic reforms that removed barriers in much of the financial sector. These efforts were at first shaky as the country struggled to adjust to financial liberalization. However, after the devaluation at the end of 1987, the Mexican economy was revamped even further with a tremendous disinflationary program. From 1988 to 1994, inflation went down from 100% to 20%. Meanwhile, the financial sector continued to be liberalized. In 1989, the government eliminated interest rate and maturity limits to deposits, as well as reducing reserve requirements for banks (eventually eliminated in 1991). Also, the Financial Groups Law was passed in 1990, paving the way for bank privatization.

The stabilization of Mexico's finances is reflected in the devaluation probability decline over the sampling period. Similarly, using a crawling peg that steadily devalued over time lessened the devaluation probability as the fixed rate inched higher. As the economy steadied, Mexico experienced more capital inflows and the real exchange rate appreciated significantly. From 1990 to 1993, Mexico received one-third of all emerging market capital inflows, primarily because of their stabilized economy and their new membership of the North American Free Trade Agreement (NAFTA). With the economy liberalized and improving, the likelihood of devaluation drastically decreased.

The devaluation probability prior to the 1994 peso crisis was calculated to be only 17.29%. However, several arguments have been made (Wilson 2000 and Agenor 1999) that the peso collapse did not stem primarily from economic fundamentals. While foreign reserve levels did decline significantly in 1994, this event occurred in conjunction with the assassination of the ruling party's candidate. As a result, capital inflows retarded as investors were wary as to whether or not the governmental transition would lead to a change in fiscal policy. Equity and debt markets, however, did not anticipate any devaluation. Lastly, the interest rate differential between the CETES and the Tesobonos (dollar indexed bill) did not increase, and remained quite small. Because the government planned to replace the CETES with Tesobonos in the middle of 1994, the differential between the two reflected the market's view on the probability of devaluation. However, this differential up to the 1994 devaluation did not reflect an increased devaluation probability.

Many of Mexico's fundamentals were, in fact, in good shape. There was very little public debt, especially in relation to GDP. Inflation was also low due to the Mexican deflationary project. Mexico maintained a conservative fiscal policy as its primary balance was in surplus since 1988, and though reserves did decline after the assassination, they remained relatively constant up until that point. However, with Mexican growth and real exchange rate appreciation, the current account deficit rose tremendously from 5.8 billion pesos in 1989 to 28.8 billion pesos in 1994. With slowed growth, compounded with a tremendous rise in US interest rates, capital inflows weakened even more so, eventually leading to outflow and an unexpected devaluation. Additionally, with the government switching to Tesobonos, it was in effect increasing foreign liabilities. In doing so, the Mexican government took foreign exchange rate risk from CETES owners. As a result, the devaluation was swift and severe, occurring before markets could react or price in devaluation probabilities.

Conclusion

Blanco and Garber's original empirical model designed to predict Mexican peso devaluation did not prove entirely successful from 1985 to 1994. The exchange rate conditional on devaluation proved to be higher than the fixed exchange rate in both 1987 and 1994. However, this conditional rate also was greater than the fixed exchange rate prior to the 1987 devaluation. This result was similar to that seen with the devaluation probabilities, which remained high until the 1987 devaluation.

This probability severely declined after 1987 and remained at low levels until the major devaluation in 1994. The failure for the model to predict this final devaluation can be attributed to its failure to include political and external factors, in addition to the basic fundamentals the model already encapsulates. Our results support arguments that the 1994 devaluation was not primarily the cause of improper economic fiscal policy and fundamentals.

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