“The Mid 1990s Peso Crisis in Mexico: A Re-examination”

Abstract

The paper examines the foreign exchange rate regime suitable for Mexico using the exchange market pressure model over the period 1971:1 - 1995:4. Different estimators are used to obtain robust results. The empirical findings indicate that an increase in domestic credit, crisis dummy and inflation rates leads to outflows of foreign reserves and/or depreciation of the peso, while an increase in foreign inflation and domestic income results in inflow of foreign reserves and appreciation of the peso. A test of the sensitivity of the exchange market pressure to its composition captured by the ratio of changes in exchange rate to foreign reserves confirms that the country absorbs exchange market pressure through the loss of foreign reserves and not through the depreciation of the peso. This suggests that a fixed exchange rate regime is optimal for Mexico. Therefore, timely external loans assistance from international institutions could have avoided the crisis; it also explains why recovery from the peso crisis after receiving external assistance was swift.

Keywords: Mexico, exchange market pressure and peso crisis.
JEL.: C22, C32, E44, E65 and F31.

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INTRODUCTION

The peso crisis that occurred in Mexico following the devaluation of the national currency in December 1994 has been studied extensively, because of the size of the country, its position as a then aspiring new member of the North American Free Trade Area (NAFTA), and the herd like effect the crisis had on countries south of it (what is also dubbed as the Tequila effect); not to mention, even the experience of South-East and East Asia and Eastern Europe in its aftermath. Incidences that indubitably precipitated the crisis that brought Mexico to the verge of outright financial crisis were the 15% devaluation of the peso above what was originally intended on 20 December 1994 and the enormity of the destabilizing activities of speculators which depleted the country of its international foreign reserves.

On the other hand, Jeffrey D. Sachs, Aaron Tornell and Andres Velasco (1996) attributed the peso crisis to a large untimely devaluation and a decline in reserves which resulted from the Banco de Mexico's attempt to prevent increase in interest rates by expanding domestic credits through different avenues. These views are contrary to Rudiger Dornbusch and Alejandro Werner's (1994) recommendation of 20% devaluation outside the exchange rate band prior to the peso crisis which was rejected by Guillermo A. Calvo (1994) as a dangerous policy likely to drive US investors to over-react against the fall in the real value of their Cetes (domestic denominated bond). See Dornbusch and Werner (1994), Guillermo A. Calvo (1994), Sebastian Edwards (1996), Calvo and Enrique A. Mendoza (1996), Francisco Gil-Diaz and Augustin Carstens (1996), Sachs et al. and Paul R. Krugman (1995).

None of these studies employed the exchange market pressure model (EMP) to analyze the peso crisis. In this paper, we have used the EMP model to find out after the fact, the mechanism by which the exchange market pressure was released prior to the crisis in December

1994, and measured the effectiveness of sterilized interventions employed by the monetary authorities (MAs) to avert the destabilizing speculation which plagued the Mexican economy in the period leading to the peso crisis. Additionally, we have estimated the EMP model to empirically shed more light to collaborate and/or reject some of the many varying views that have been attributed to the peso crisis[1]. In fact it is found that the chief mechanism by which the Mexican MAs absorb external pressure was through the loss of international reserves. This means that devaluation which some policymakers and international institutions strongly recommended for Mexico in the immediate months preceding the crisis contributed to it.

Following the introduction, is a brief review of the activities in Mexico before the crisis in section 1. In section 2, the exchange market pressure model is developed. The empirical evidence is presented and discussed in section 3, and the study is summarized and concluded with some policy recommendations in section 4.

1. Activities before December 1994

In no year in the history of Mexico has there been a flurry of activities that fed speculation as it was in 1994. Gil-Diaz and Carstens (1996) argued that these activities which could be summed up as financial reform, political shocks, and external factors were the primary cause of the peso crisis. The speculative pressure on the peso started in 1993 when the US Congressional debates placed Mexico's accession to NAFTA in doubt. This was followed by the 1994 election, its associated campaigns and accession of Mexico to the NAFTA. It was further intensified by the Chiapas' insurrections to influence the outcome of the 1994 election.

In March 23, 1994 Luis Donaldo Colosio, the incumbent political party's presidential

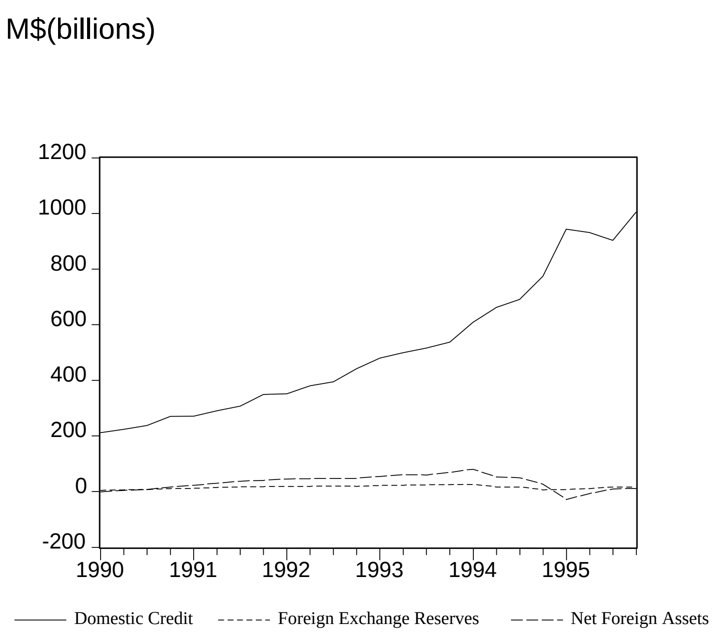
[1] There have been many other studies and comments on the Mexican crisis after the Dornbusch and Werner's study. We have not reported them here to conserve space.

Table 1: Some important economic indicators

Year	BB (M$b)	HCE (M$b)	GCE (M$b)	CAB (US$b)	OB (US$b)	M1 (M$b)
1990	-18.67	514.12	61.95	-7.45	2.22	50.95
1991	27.69	669.16	86.16	-14.89	7.97	113.63
1992	46.92	808.12	111.75	-24.44	1.74	131.73
1993	6.45	903.17	138.56	-23.40	7.23	157.04
1994	- 0.39	1016.13	164.16	-29.66	-17.20	163.83

Notes: BB is balance budget, HCE is household consumption expenditure, GCE is government consumption expenditure, CAB is current account balance, OB is overall balance, M1 is narrow definition of money supply, b is billions, m is millions, - denotes deficits, and M$ is Mexican pesos. The data is taken from Washington based International Monetary Fund's (IMF) **International Financial Statistical Yearbook** 2000.

Figure 1: Graphs showing domestic credit (__), foreign exchange reserves (…)and net foreign assets (_.) in billions pesos (M$), 1990:1 - 1995:4.



candidate was assassinated, and a month later the destabilizing activities of speculators were fended off by the MA through intervention which according to Gil-Diaz and Carstens (1996) raised the Cetes' interest rates - London inter-bank offer rates (LIBOR) differential above 10%. Amidst this development, the government which was bent on gaining entry to the NAFTA introduced financial reforms by abolishing (i) the reserve requirement rate, (ii) the withholding tax rate on foreign borrowing, and (iii) restrictions on foreigners to hold Mexican government bonds (Cetes, Bondes and Tesobonos) by liberalizing the capital market. Note that the government had liberalized the capital market to allow foreigners to invest in treasury bonds and preferred stocks in most sectors of the economy in 1990. As a result, treasury bills' rates and the average cost of funds fell from 34.8% and 37.1%, respectively, in 1990 to 14.1% and 15.5%, respectively, in 1994. From 1990 - 1994, the narrow and broad money supply, M1 and M2, grew by 221.5% and 104.6%, respectively.

Unfortunately, these sweeping liberalization policies were not preceded by sound regulatory and supervisory machinery. As a result, there was a laxity in banking safeguards and associated imprudent practices caused public sector loans-GDP ratios of Development Banks to grow by 3.6% from previous 3% level in 1993, and private expenditures-GDP ratios grew by 5.9% in December 1994. These developments contributed to moral hazard problems. These hurried reforms which occurred in the midst of an election campaign were indirect-attempts by the incumbent government to expand the economy without monetizing fiscal deficits to surreptitiously influence the electorate. Fiscal expansion as argued by Krugman (1995) caused the budget balance to fall from a surplus of M$46,921m in 1992 to a deficit of M$386m in 1994, despite Gil-Diaz and Carstens' (1996) contention that public expenditures-GDP ratios fell by 0.5% in 1994. As shown in Table 1, households and government consumption expenditures grew by 97.6% and 165%, respectively, from 1990 - 1994.

The Mexican economy became financially fragile as a result of the politically induced financial reforms in 1994.[2] Moral hazard problems increased and adversely affected the MA's readiness and ability to intervene in the foreign exchange market to defend the peso which was under a severe pressure because of the active sale of Tesobonos (dollar-denominated bonds) to foreigners who were mostly US nationals by the banks. Calvo and Mendoza (1996) argued that the Mexican debt was 5.5 times larger than its net international reserves, and the foreign denominated debt (Tesobonos) was about twice the net international reserves in 1994. See also Ronald I. McKinnon and Huw Pill (1996) and Table 3 of Sachs (1996). The foreign exchange reserves of US$25.9b in the first quarter of 1994 dropped to US$6.3b by the close of 1994 below the US$10b which was the Bank of Mexico's required minimum threshold of tolerance, and was inadequate to support sterilized intervention. As a result, the MA could not use sterilized interventions to defend the peso. Therefore, news of smoldered Chiapas' insurrections and accusations of a former Assistant Attorney General, *inter alia*, pointed out by Gil-Diaz and Carstens (1996), important factors as they were, could not have single-handedly tipped off speculation to cause the peso crisis that followed in December 1994 after renewed rumors of Chiapas' insurrection.

The fall in the foreign exchange reserves below the required minimum threshold of US$10b made the MAs simply ill prepared to defend the peso with sterilized intervention policies because of the events outlined above[3], and according to Pedro Aspe Armella (1995)

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[2] According to Calvo and Mendoza (1996), surging capital inflows, combined with radical financial liberalization induced a lending boom which made Mexico vulnerable to financial fragility.

[3] See Calvo and Mendoza (1996), McKinnon and Phill (1996), Sachs, et al. and Andres Velasco (1996) and Krugman and Maurice Obstfeld (2000).

there were several attempts by the MAs to sterilize the exchange rate. But the nagging question is, why did sterilize interventions succeed to stabilize the peso in 1993 but failed in 1994? Was the peso crisis caused by the Mexican government's mistaken adherence to a pegged exchange rate regime, a regime which although useful in fighting inflation in the 1980s[4], simply outlived its usefulness in 1994 as argued by Sachs (1996)? Could different timing and margin of the devaluation have eased off the exchange market pressure to avert the ensuing peso crisis? These issues have been examined empirically by estimating an EMP model and using it to answer the list of questions above by: (i) measuring the response of Mexico to external monetary variations, (ii) finding out the optimal exchange rate regime at that time, and finally, (iii) explaining why devaluation recommended by the Washington-based institutions and some experts, failed to effectively absorb the country's external monetary fluctuations during the last quarter of 1994.

2. The Model

The main economic developments that have been proposed to deal with external imbalances of countries can be traced from the 'elasticities' approach to balance of payments which was pioneered by Joan Robinson (1937) for conditions of deep depression and mass unemployment in the 1930s. It was followed by the Keynesian multiplier approach by Arnold C. Harberger (1950), which was later modified into the 'absorption approach' by Sidney S. Alexander (1952). The 'economic policy' approach was independently developed by James Meade (1951) and Jan Tinbergen (1952) to extend the existing model to deal with the twin policy objectives of internal and external balances. Unfortunately, it failed to treat the role of domestic monetary policy in correcting external imbalances.

The monetary approach to the balance of payments was developed by several economists

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[4]The exchange rate was fixed only in 1987 as a part of extensive reforms and exchange rate policies to reduce inflation from its peak of 159% in 1987 to 7% in the last quarter of 1994.

to treat the role of domestic monetary policy. See J. Polak (1957), Harry G. Johnson (1977), Jacob A. Frenkel and Harry G. Johnson (1976), Robert Mundell (1971) and Rudiger Dornbusch (1973), to name a few. The monetary approach views the balance of payments as a monetary phenomenon. It maintains that payments imbalances reflect stock disequilibria between the supply of and demand for money, and the latter is assumed to be a function of national income. Balance of payments are assumed to operate as safety valves which open up automatically either to remove excess supply of money which results from balance of payments deficits or to admit additional national money supply in the form of balance of payments surplus in response to excess demand for money. Thus the 'monetary approach' is very similar to David Hume's (1963) price-specie-flow mechanism as both views deal with a self-correcting mechanism of monetary flows associated with balance of payments deficits and surpluses. But, unlike the 'monetary approach' which operates through both demand for and supply of money, Hume's price-specie-flow operates through commodity prices. Thus the import-demand elasticities which are important lubricant for the smooth functioning of the price-specie-flow mechanism are not crucial for the 'monetary approach'.

The 'monetary approach' assumes that the best way of analyzing macroeconomic phenomena is by using both demand for and supply of money. It also assumes that the world does not consist of separable national economies but instead, it is an integrated closed economy. As a result, there is a perfect commodity arbitrage which ensures that the law of one price holds in integrated world commodity market. See Johnson (1977) and Marina von Whitman's (1975) survey.

The EMP model was developed by Lance Girton and Don Roper (1977) for Canada as a synthesis of monetary approach to balance of payments and monetary approach to exchange rate determination for a small open economy which takes the world prices as given. The EMP model is defined as the mechanism by which a dependent variable consisting of changes in exchange rates and foreign reserves absorbs the ‘pressure’ exerted by external imbalance when there is excess (or diminish) growth in the money supply of a country relative to money demand under a dirty float regime. See Girton and Roper (1977, p.537) and M. Connolly and J.D. da Silveira (1979, p.448).

Diana N. Weymark (1997, p.59) defines the EMP as a measure of ‘the total excess demand for a currency in international markets as the exchange rate change that would have been required to remove this excess demand in the absence of exchange market intervention, given the expectations generated by the exchange rate policy actually implemented.’ She argues that her definition removes the basic problems inherent in the Girton-Roper model, namely: (i) the latter’s model is derived from restrictive monetary model as a result it is not malleable to be applied to other models, and (ii) the latter’s methodology is based on a model dependent definition which makes it arbitrary as it fails to identify a unique formula for measuring intervention activity. Upon a careful review of both studies, we have decided to use the Girton-Roper model because their methodology is simpler, and easy to derive without sacrificing substance and intent of the model. Additionally, unlike Weymark’s intervention index, the EMP model does not rely on definition of forward looking expectation, which is arbitrary at best[5] to calculate.

In theory, the EMP model is a two country single equation which basically shows that exchange market pressures are absorbed either through loss of (gain in) foreign reserves or

[5] Note that any model that employs rational expectation is in theory not arbitrary because of the conditioned all available information; however, in empirical studies the conditioned all available information depend on the specific model in question. This means that different researchers may use different variables to define the conditioned all available information so the resulting intervention index from Weymark’s computed intervention index will at best

depreciation/devaluation (appreciation/revaluation) of the exchange rate. It is therefore a useful means to empirically test the exchange rate regime practiced by a country, and measure the degree of monetary autonomy. Note that under a flexible exchange rate regime, exchange market pressures are absorbed by depreciation, whereas under a fixed exchange rate regime such pressures are absorbed by loss of foreign reserves.

The EMP model has also been applied to study the economic situation of Brazil by Connolly and da Silveira (1979), Argentina by Nelson C. Modeste (1981), Korea by I. Kim (1985), Costa Rica by J. Thornton (1995), G7 by M. Bahmani-Oskooee and D. Bernstein (1999), and Jamaica by Edward E. Ghartey (2002).[6]

To derive the EMP model, we first specify a stable money demand for Mexico in the classical tradition as a function of real income (Y) and national price (P) as follows:

$$L = k.P.Y \qquad (1)$$

where, k is the Cambridge constant. This specification eliminates interest rates to avoid simultaneous equation bias problem, since capital flows affect domestic interest rates which are likely to be endogenous in the EMP model. See Maurice Obstfeld (1982), Connolly and da Silveira (1979), and Girton and Roper (1977).

The money supply is specified as a function of domestic credit (DC) and foreign reserves (FR) which are consolidated from the banking system. The liabilities of the banking system consolidated from the central and private banks are denoted by the money stock (M). The resulting identity for the money supply is

$$M = mm(FR + DC) \qquad (2)$$

where, mm is a constant money multiplier, and (FR + DC) is the resulting base money.

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be arbitrary. We therefore defer her intervention index to be used for similar study in the future by other researchers.

[6] As pointed out by a referee, Evans Tanner (2001) has employed the EMP model in a vector autoregressive

The exchange rate is defined as

$$E = P/P^f \quad (3)$$

where E is the nominal exchange rate which describes the peso denominated value of the US dollar, and P^f is the foreign or US prices. The US is used as the reserve country, and Mexico a member of the NAFTA is assumed to be a small open country that faces a fixed price level in spite of its absolute size. Thus, it is assumed that in case of any need for official settlement adjustment, Mexico will be forced to bear the burden of adjustment.

By invoking the Walras Law, the monetary inter reaction when money supply is equal to demand from equations (1) and (2), respectively, yields

$$mm(FR + DC) = k.P.Y \quad (4)$$

Equation (4) is then expressed in percentages, and the left hand side of equation (4) becomes

$$(\Delta M/M) = \Delta FR/(FR + DC) + \Delta DC/(FR + DC) \quad (5a)$$

The right hand side of equation (4) can also be expressed in percentages as

$$(\Delta E.k.P^f.Y)/(k.E.P^f.Y) + (\Delta P^f.k.E.Y)/(k.E.P^f.Y) + (\Delta Y.k.E.P^f)/(k.E.P^f.Y)$$

$$= (\Delta E)/(E) + (\Delta P^f)/(P^f) + (\Delta Y)/(Y) \quad (5b)$$

But the rate of change or percentage changes expressed above can also be expressed as

$$\Delta lnE = (\Delta E)/(E); \Delta lnP^f = (\Delta P^f)/(P^f); \Delta lnY = (\Delta Y)/(Y) \quad (5c)$$

Equation (4) is therefore expressed in terms of percentage changes by using equations (5a-5c) as follows:

$$\Delta FR/(FR + DC) + \Delta DC/(FR + DC) = \Delta lnE + \Delta lnP^f + \Delta lnY \quad (6)$$

It is further expressed as an exchange market pressure (EMP) model as follows:

$$\Delta FR/(FR + DC) - \Delta lnE = - \Delta DC/(FR + DC) + \Delta lnP^f + \Delta lnY \quad (7a)$$

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framework for group of countries which include Mexico.

where,

$EMP = \Delta FR/(FR + DC) - \Delta lnE$

But

$lnY = lny – lnP$; where, y = nominal GDP or GNP

Thus (7a) can be expressed as

$$\Delta FR/(FR + DC) - \Delta lnE = - \Delta DC/(FR + DC) + \Delta lnP^f + \Delta lny - \Delta lnP \quad (7b)$$

Since (7b) is an identity, we have expressed it in a general form as follows[7]:

$$\Delta FR/(FR + DC) - \Delta lnE = - \beta_1\Delta DC/(FR + DC) + \beta_2\Delta lnP^f + \beta_3\Delta lny - \beta_4\Delta lnP + \nu \quad (8)$$

where, all the parameters are nonnegative. Note that the right-hand side variables ($\Delta Fr/(FR + DC) - \Delta lnE$) constitute the EMP and because the EMP is the dependent variable of (8), its coefficients are constrained to unity. This means that an increase in domestic credit which is the offset coefficient variable will result in either an outflow of foreign reserves or depreciation or both. There is complete offset if $\beta_1 = 1$, and absence of offset when $\beta_1 = 0$.

By substituting lower case letters for the logarithmic variables, and adding a first quarter seasonal dummy (s1), a crisis dummy (DUMMY) to improve the functional form of the estimated equation, the EMP model which is finally estimated for Mexico is as follows:

$$\Delta FR/(FR + DC) - \Delta e = - \lambda\Delta DC/(FR + DC) + \alpha_0\Delta p^f + \alpha_1\Delta y - \alpha_2 DUMMY + \alpha_3 s1 - \alpha_4\Delta p + \varepsilon' \quad (9)$$

where all the parameters are nonnegative, ε' is the error term, and the offset coefficient λ is unity and measures the extent of monetary policy independence in the country. A significant negative unit coefficient of λ, with the rest of the explanatory variables being insignificant, means if Mexican monetary authorities increase money growth, they will face either depreciation of the

[7]See the Appendix for an alternative derivation of the EMP model which is conditioned on the fact that the foreign reserves are positive over the sample period.

peso or lose foreign reserves, or face both depreciation and loss of foreign reserves. However, if the monetary authorities increase the base money by buying domestic assets through open market operations, then they can fix the exchange rate only if they raise the foreign reserves to the same extent as the initial increase in the base money. Thus, under a pegged rate, the Banco de Mexico's scope to pursue an independent monetary policy will be restricted by the availability of adequate foreign reserves.

Equation (9) also shows that an increase in income and foreign inflation rates, and a fall in national inflation rates and crisis dummy, *all other things being equal*, will either cause the exchange rate to appreciate or an inflow of foreign reserves or both. The converse holds true.

The sensitivity of the EMP to its composition allows us to measure and test the policy reaction of the Mexican MA. It is estimated by adding MW which is defined as the ratio of exchange rates to foreign reserves as a regressor to the expression in equation (9). If the coefficient of MW is negative and significant, then *all other things being equa*l, the EMP is sensitive to its composition so the Banco de Mexico absorbs exchange market pressure by losing foreign reserves. This policy reaction is consistent with an optimal pegged exchange rate regime. If the coefficient of MW is positive and significant, then the monetary authorities absorb exchange market pressures by depreciation, so a floating rate regime is optimal. An insignificant coefficient of MW means that exchange market pressures are absorbed by both depreciation/devaluation and loss of foreign reserves so the optimal exchange rate regime for the country is a ‘dirty’ float.

Data sources are the various issues of the IMF’s **International Financial Statistical Yearbooks**, and the web-site of the Federal Reserve Bank of St. Louis. The sample period covered is 1971.1-1995.4, making the sample size 96 without accounting for leads and lags..

3. The Empirical Evidence

The empirical evidence is reported in Table 2. We have reported results from four different estimators to ensure the robustness of the empirical findings, namely: least squares (LS), dynamic least squares (DLS), two-stage least squares using instrumental variables (IV),

Table 2: Estimates of the EMP model with (ΔFR/(FR + DC) - Δe) as a dependent variable, 1974:1-1995:4

Vars.	LS	DLS	IV	DIV
ΔDC/(FR+DC)	- 1.01	- 1.01	- 1.01	- 1.01
	[3.35]*	[2.22]*	[3.35]*	[2.22]*
Δp^f	0.21	0.21	0.21	0.21
	[0.12]	[0.14]	[0.12]	[0.14]
Δp	- 0.92	- 0.92	- 0.92	- 0.92
	[2.09]*	[3.89]*	[2.09]*	[3.89]*
Δy	0.63	0.63	0.63	0.63
	[1.36]	[2.78]*	[1.36]	[2.78]*
DUMMY	- 0.16	- 0.16	- 0.16	- 0.16
	[2.95]*	[2.26]*	[2.95]*	[2.26]*
S1	0.06	0.06	0.06	0.06
	[1.40]	[2.68]*	[1.40]	[2.68]*
Int	0.01	0.01	0.01	0.01
	[0.20]	[0.15]	[1.20]	[0.15]
R^2	0.35		0.35	
DW	1.67		1.67	
F(k, n-k-1)	7.18*		7.18*	
$\chi^2_{SC}(4)$	2.63		2.63	
$\chi^2_{FF}(1)$	2.10		2.10	
$\chi^2_{H}(1)$	1.45		1.45	
$\chi^2_{SG}(3)$			0.38	

Notes: LS is least squares, DLS is dynamic least squares, IV is a two-stage least squares (2SLS) based on instrumental variables, and DIV is dynamic 2SLS based on instrumental variables. χ^2_{SC} is based on the Lagrange multiplier test of residual serial correlation, χ^2_{FF} is based on Ramsey's RESET test using the square of the fitted values, and χ^2_{H} is based on the regression of squared residuals on squared fitted values, and χ^2_{SG} is based on Sargan's legitimacy test. The instruments are ΔDC/(FR + DC), Δp^f, Δp, Δy, DUMMY, s1, intercept, MWA and Δy(-1). R^2 is the adjusted coefficient of determination, and DW is Durbin-Watson statistic. DLS and DIV are based on Newey-West adjusted standard errors and Parzen’s weights with truncation lags of 40. DUMMY = 1 for 1974.1, 1982.1, 1982.4, 1982.4, 1984.1, 1991.1, 1992.1, and 1994.4; and zero otherwise. The notations *, **, and *** denote significance at 0.01, 0.05 and 0.10 levels, respectively. T-ratios are reported in square brackets, k is number of independent variables and n is the number of observation and is 88.

and dynamic two-stage least squares using instrumental variables (DIV). Results of DIV are simply two-stage least squares using IV results where respective t-ratios of regressors are estimated by employing the Newey and West (1987) technique which uses Parzen's window with truncation lags of 40 to obtain a more general positive semi-definite covariance matrix to correct for different forms of autocorrelation and heteroscedasticity problems. Note that the result of DIV is also consistent with the LS result. The leading estimated equation is therefore the DIV result in Table 2.

The estimated EMP model is well explained by changes in domestic credit, foreign and national inflation rates, growth in income, first quarter seasonal dummy, and a crisis dummy variable which captures events which occurred during 1974.1, 1982.1, 1982.4, 1984.1, 1991.4, 1992.1and 1994.4. The periods, 1974.1 and 1991.4 represent financial liberalization; 1982.1 and 1992.1 represent the beginning of banking crisis; 1984.1 represents the peaking of the banking crisis; 1982.4 and 1994.4 represent the closest balance of payments crisis. See Graciela L. Kaminsky and Carmen M. Reinhart (1999).

We have reported and discussed the following diagnostic tests: χ^2_{SC} is based on the Lagrange multiplier test of residual serial correlation – and it is used to test for serial correlation; χ^2_{FF} is based on Ramsey's RESET test using the square of the fitted values – and it is used to test whether the functional form of the model is correct; χ^2_{H} is based on the regression of squared residuals on squared fitted values – and it is used to test for heteroscedasticity problems; and finally, χ^2_{SG} is based on Sargan's legitimacy test – and it is used to validate the relevance of the instrumental variables used to estimate the two stage least squares.

The diagnostic tests indicate that the estimated results reported and discussed in the paper are correctly done and are not adversely affected by any of the standard econometric problems. Additionally, the results are reasonable and conform to a priori expectations from economic theory.

The impressive diagnostic tests reported in Table 2 indicate that our results are robust. The DIV result indicates that inflation rate, change in domestic credit, and crisis DUMMY variable lead to outflow of foreign reserves and/or depreciation of the Mexican peso, while foreign inflation and growth in income and the first quarter seasonal dummy lead to inflow of foreign reserves and/or appreciation of the Mexican peso, although foreign inflation is not significant. The estimated offset coefficient $\Delta DC/(FR + DC)$ is -1.01 and is significant at 0.05 levels, which means that there is a complete offset over the period of study. This means that the MA in Mexico can offset any external monetary variations with sterilized interventions as the offset coefficient is complete.

The DIV result which measures the sensitivity of exchange market pressure to its composition (denoted by MW) is then estimated by using Δdc, Δp^f, Δp, Δy, DUMMY, s1, intercept, MW and $\Delta y(-1)$ as instrumental variables to yield the following:

$$\begin{aligned} \Delta FR/(FR + DC) - \Delta e = {} & - 1.03[3.37]^{*}\Delta DC/(FR + DC) + 0.23[0.13]\Delta p^f - 0.87[1.94]^{**}\Delta p \\ & + 0.58[1.22]\, \Delta y - 0.16[2.97]^{*}DUMMY + 0.06[1.30]s1 \\ & - 0.01[0.29] - 6.16[1.85]^{***}MW \qquad (11) \end{aligned}$$

$R^2 = 0.35$, DW = 1.67, F(8, 80) = 6.17*, $\chi^2_{SC}(4) = 2.33$, $\chi^2_{FF}(1)= 2.27$, $\chi^2_{H}(1)= 1.44$, and $\chi^2_{SG}(3) = 0.44$

The diagnostic statistics χ^2_{SC} and χ^2_{H} indicate that there are no serial correlation and heteroscedasticity problems. Sargan's legitimacy test (χ^2_{SG}) validates instruments of the IV estimator. The Ramsey's RESET test (χ^2_{FF}) shows that the functional form of the model is correct. Although there are no autocorrelation and heteroscedasticity problems, we have used the DIV estimator which employs the Newey-West technique to provide correction to those problems and simultaneous equation bias problem. The instrumental variables used in the DIV estimates do not have any independent explanatory power which exceeds that of the dependent variables. The t-ratios are reported in the square bracket. See notes in Table 2.

The coefficients of Δdc, DUMMY and MW are significant at 0.01 levels, whereas the coefficient of Δp is significant at 0.05 levels. The offset coefficients in Table 2 and equation (11) range from - 1.03 to - 1.01 and are significant meaning that the monetary policy in Mexico is effective and autonomous. Note that the offset coefficient of Mexico compares favorably with

Brazil's -1.01 obtained by Connolly and da Silveira (1979), and Canada's -0.94 obtained by Girton and Roper (1977), all of which were found to be significant.

The magnitude of the negative coefficient of MW in equation (11) shows that the exchange market pressure model is sensitive to its composition, although it is significant at 0.10 levels. This means that in Mexico exchange market pressures are absorbed by the loss of foreign reserves, although the significant level of the result is weak. Therefore, for Mexico to successfully intervene in the foreign exchange market to maintain the exchange rate of the peso within its band, it must have substantial foreign reserves. The complete offset coefficient of -1.0 and the coefficient of MW which is -6.16 imply that market interventions are effective over a sustained period in Mexico.

Monetary policy in Mexico was autonomous from foreign monetary developments in the period leading to the mid 1990s crisis. It could use sterilized intervention to completely stem outflows of foreign reserves, but it was required to have adequate foreign reserves. However, during the peso crisis in the mid 1990s, because of inadequate foreign reserves, the country had huge proportion of its liabilities in foreign currency, and because the financial market of the US, its next door neighbor and immediate competitor, was thriving at that time, the MA in Mexico could not effectively sterilize to fend off loss of reserves forced upon the country by speculators, especially the US investors. Mexican households and foreign investors in fear of losing their assets' value during the period of the crisis, disposed off domestic bonds for foreign currency[8] to reduce the proportion of private bond holdings in their portfolios. As a result, domestic credits of banks increased sharply, and intensified capital outflows which lead to loss of foreign reserves, and precipitated a balance of payments crisis. As a result, the overall balance of payments surplus of US$7.2m in 1993 plunged into a deficit of US$17.2m by the close of 1994. See Figure 1. This caused the country to experience its worst credit crunch and severe asymmetric information problems, which led to bankruptcies and a near financial crisis during the period.

[8]Foreign currency denominated in Mexican dollars rose to its peak at M$193.9b in 1994 from M$53.1b in 1993, a growth rate of 265%.

4. Conclusion

Results of offset coefficients show that monetary autonomy exists in Mexico in the period leading to the peso crisis in the mid 1990s. The country's monetary policy is dependent on foreign monetary developments. These findings confirm Armella’s (1995) admission that there was sterilized intervention but it was either weak or ineffective, as its potency rested on availability of adequate accumulation of foreign reserves with the central bank.

The significance of the offset coefficients from the empirical findings indicates that exchange market pressures caused by increase in domestic credit could be absorbed through loss of foreign reserves, although the result is rather significant at 0.10 levels. This suggests that a fixed exchange rate regime is optimal for Mexico and was consistent with the exchange rate regime operating in the country during the crisis period. Changes in exchange rates (or devaluation of the peso) which were advised for the country at that time were ineffective in absorbing such exchange market pressures. Therefore, neither the timing nor the size of the devaluation of the peso could have caused or averted the peso crisis as argued by some experts. Rather, Mexico faced an imbalance between foreign denominated short-term debt and foreign reserves shortage problem which made sterilized interventions ineffective.

Note that sterilized interventions to absorb exchange market pressure through loss of foreign reserves succeeded in 1993 because accumulated of foreign reserves was adequate in the central bank. Capital inflows raised foreign reserves to US$30b during the period. However, in December 1994, capital inflows dropped to US$5b, and foreign reserves were US$6.3b, which were far below the country’s minimum threshold of tolerance of US$10b to support the sterilized intervention policy of the MA.

Additionally, foreign owners of Tesobonos who were mostly US retirees had a short holding period and were jittery. During the period, expectations of US treasury bills’ rates were rising, which made Mexican securities less attractive to international investors, and the growing Mexican government spending because of the elections reduced the national budget from a surplus into a deficit in 1994, and only added to the misfortunes of investors. These developments and the rising political and country risks exacerbated the external imbalance, which caused speculators to drive the peso into such magnitude of crisis as the country experienced with its attending herd-like effect.

It is therefore important to note, that because a fixed exchange rate regime is optimal for Mexico during the period leading to the crisis, it needed adequate foreign reserves to make sterilized interventions effective for it to absorb exchange market pressures successfully. This explains why it recovered from the peso crisis rather quickly when Clinton's Administration and the IMF extended it US$52b loan assistance in foreign reserves in January 1995. The lesson from the Mexican experience therefore is that, if international institutions had acted as a lender of last resort and extended it adequate foreign reserves on time, when events led to the depletion of the country’s foreign reserves below the minimum threshold of tolerance set by the MA, instead of experts and international institutions insisting on them to devalue their currency, the entire peso crisis with its attending herd-like effect could have been averted.

Appendix: Alternate derivation of the EMP model conditioned on the fact that net foreign reserves are positive.

Growth in the money supply:

$$\Delta m^s = \Delta fr + \Delta dc \qquad (A1)$$

Growth in money demand:

$$\Delta m^d = \Delta p + \Delta Y \qquad (A2)$$

Relative purchasing power parity (PPP):

$$\Delta e = \Delta p - \Delta p^f \qquad (A3)$$

All small case letters denote logarithmic forms of variables.

At equilibrium: $\Delta m^s = \Delta m^d$

$$\Rightarrow \quad \Delta fr + \Delta dc = \Delta p + \Delta Y \qquad (A4)$$

By substituting for Δp in equation (A3), equation (A4) becomes:

$$\Delta fr + \Delta dc = \Delta e + \Delta p^f + \Delta Y \qquad (A5)$$

But growth in real income is $\Delta Y = \Delta y - \Delta p$

So equation (A5) can be expressed as

$$\Delta fr + \Delta dc = \Delta e + \Delta p^f + \Delta y - \Delta p$$

$$\Rightarrow \quad \Delta fr - \Delta e = -\Delta dc + \Delta p^f + \Delta y - \Delta p \qquad (A6)$$

Equation (A6) is a specific equation which can be expressed in a more general form as

$$\Delta fr - \Delta e = -\lambda\Delta dc + \alpha_1\Delta p^f + \alpha_2\Delta y - \alpha_3\Delta p + \varepsilon \qquad (A7)$$

Girton and Roper define the EMP as ($\Delta fr - \Delta e$), which is the left hand-side dependent variable. Weymark (1997, pp.59-62) defines the EMP as $\Delta fr + \varphi\Delta e$, where φ ($= -\partial\Delta e/\partial\Delta fr$) is the model specific elasticity. To improve the functional form of the estimated equation for Mexico, we have added a first quarter seasonal dummy (s1), and a crisis dummy (DUMMY) to equation (A7) to obtain the following equation:

$$\Delta fr - \Delta e = -\lambda\Delta dc + \alpha_1\Delta p^f + \alpha_2\Delta y - \alpha_3\Delta p + \alpha_4\Delta s1 - \alpha_5 DUMMY + \varepsilon \qquad (A8)$$

The left hand-side of equation (A8) is restricted to have a coefficient of unity because it is the dependent variable.

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