To what extent did the causes of the currency crisis lead to the exchange rate rate volatility of the peso?

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Abstract

This study focuses on the decision made by the Mexican government in December 1994, to transition from a fixed exchange rate regime to a floating exchange rate regime. This research shows, the impact this decision had on the economy, leading it to what is classified as a currency crisis and peso volatility. The contribution of this paper to the existing literature of this topic is to examine whether other macroeconomic variables influenced this decision, contributing to the volatility that was found. Therefore, this paper hopes to prove or confirm the direction of causes in the variables, that is, if the independent variable caused the dependent or if the dependent caused the independent variables. Evaluating the direction of causality may aid in explaining phenomenon about the Mexican economy such as the tequila effect, the uncommon factor in the traditional theory of a crisis.

Section 1

1. Introduction

"Volatility is a symptom that people have no idea of the underlying value"

– Jeremy Grantham

A mismanagement of macroeconomic policies provokes a destructive collapse in an economic system, which often pertains from a dependency on external variables, creating an instability. To expound on this statement, an economy whose government does not impose rigorous monetary and fiscal policies to domain its domestic economy, or whose economy depends on commodities, such as oil or gas, to generate economic growth, is susceptible to disintegrate. Often the impact of such decisions seen in the financial sector. Traditionally, the branch of international finance in economics focuses on the monetary and macroeconomic interactions between two or more countries, whilst analysing financial systems.

Therefore, the purpose of this paper is to investigate and provide an explanation of the transition and expound on the extent to which the peso was volatile during its currency crisis. A preliminary analysis will be provided on the role of the exchange rate in the economy and its determinants, whilst exploring the reasons for the volatility. The nature of the crisis will be studied in depth, in the literature review. Moreover, a country such as Mexico, that exercised a fixed exchange rate regime, inevitably decided to give up their domestic monetary autonomy[1] because fixedness of the regime behaved as a constraint. In this case, the Mexican economy was pegged to the US dollar, a characteristic of this type of regime entails it is not volatile, maintaining the stability of the currency.

However, towards the end of 1994 'the foreign exchange commission determined that the exchange rate would be determined by market forces (floating exchange rate)' (BDM, 2019). This means that the exchange rate policy changed, and the impact of it should not go unnoticed, because this change will provide insight on how macroeconomic instruments behave. There is a significant divide between policy-makers and economists regarding the impact of foreign exchange policies on growth (Habib, Mileva, & Stacca, 2016), this will be explored further.

[1] Monetary refers to the independence of a country's central bank to affect its own money supply and, through that, conditions in its domestic economy (Suranovic, 2010) .

This transition was characterised as a currency crisis and lead to the exchange rate volatility. Consequently, this paper explores the reasons for this transition and if they impact other macroeconomic variables.

The Mexican Peso crisis of 1994, informally known as the Tequila crisis, was sparked by a sudden devaluation of the peso. Unfortunately, the crisis became an example of the result of a combination of lax monetary and fiscal policies. Another characteristic of the crisis is that the Tequila effect is a synonym for the contagion effect the economy had on surrounding countries. Due to the importance of this characteristic, it is mentioned in this paper, however it will not be the focal point because this paper studies the extent to which such a decision led to the currency crisis and the impact this had on the domestic economy. To comprehend the mechanisms of this crisis, this paper will first introduce basics such as the definition, determinants and how to calculate the exchange rate; then the volatility will be defined (causes and effects) and a distinguishing of the different types of financial crisis.

Exchange rates are described as the value of one currency over the value of another, this also defines the nominal exchange rate. There are operational differences between fixed and floating exchange rates. A fixed exchange rate refers to a system in which a monetary authority announces buying and selling rates for its currency in terms of a foreign currency and promises to trade unlimited amounts at that rate (Obstfeld & Rogoff, 1995). Whilst a floating exchange rate occurs when the national monetary authority allows the exchange rate to be determined by market forces (Kingston, 2006) as mentioned. Freidman (1953), argued that flexible exchange rates are preferable to fixed exchange rates on the grounds they provide greater insulation from foreign goods (Devereux, 1998), this protectionism argument, ensures emerging markets are not as vulnerable. There are also other types of foreign exchange transactions that are used, one of which is the forward transaction- this is an agreement to buy or sell foreign exchange for future delivery at a price determined today (Aliber, 2011), but this will not be used in this paper.

Since floating exchange rates are determined by market forces, a simplistic version of exchange rate is explained with the demand and supply graph, as the following shows.

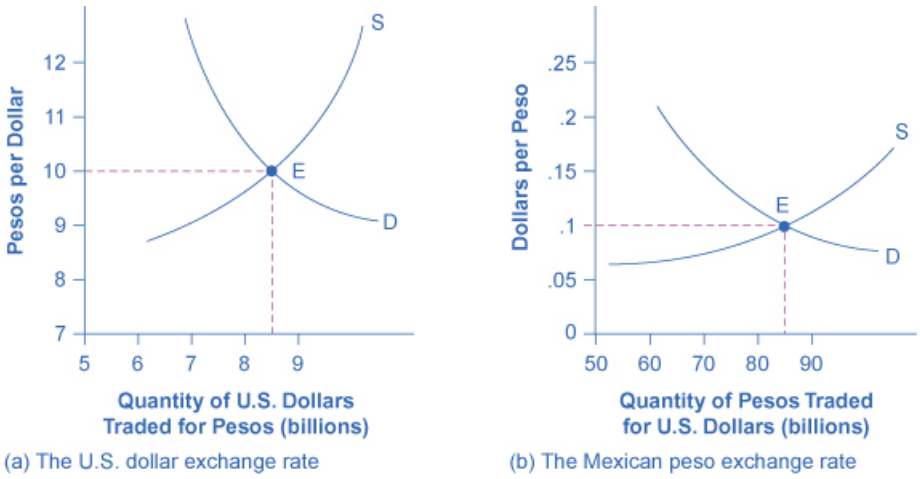

FIGURE 1 DEMAND AND SUPPLY EXCHANGE RATE (MANKIW, 2011).

Figure (1) shows that the equilibrium rate is at the point of intersection for the supply and demand. Graph A shows the demand and supply from the US perspective and graph B is for the Mexican peso; note, an increase in demand for either would result in an appreciation of the currency and a decrease would result in a depreciation. A nation's demand for foreign exchange is derived from, or corresponds to, the debit items on its balance of payments (Carbaugh, 2009).

This conversion of currencies occurs in a foreign exchange market, it is not a physical market rather it is defined as a market where the various national currencies are bought and sold (Pilbeam, 2013), in the foreign exchange market, the dominant currency is the dollar. Hence, this paper will additionally devote references to the US and its economy as it is the dollar is the de facto global currency and reserve currency. The dollar performed in a dual role as it has served as the national currency of the United States and a key currency of the world economy (Schulmeister, 2015).

Nonetheless, there are different methods of calculating either the nominal or the real exchange rate. The nominal exchange rate is simply the domestic currency divided by the foreign currency, whereas the real exchange rate is the nominal exchange rate adjusted for relative prices between the countries under consideration (Pilbeam, 2013), this relates to the purchasing power parity theory. The importance of distinguishing between types of exchange rates is because policy makers and economists can utilise this information to analyse the impact on the economy, particularly, the balance of payments, an important indicator of a currency crisis for the first generational models, this will be explained further.

Although, both techniques of calculating the exchange rate will be used simultaneously, there is an additional type which policy makers benefit the most from, which is the effective exchange rate. The effective exchange rate is a sure measure of a currency's appreciation or depreciation against the weighted basket of foreign goods (Pilbeam, 2013); note that this is often determined by the importance of trade with other nations. This is useful as it emphasises the relationship between fluctuations that occur in the US dollar and its influence on the Mexican economy.

This leads to the next point, which is the Purchasing Power Parity, Cassel (1918) articulates that the absolute version of PPP postulates that the relative prices (in different currencies and locations) of a common basket of goods will be equalized when quoted in the same currency (Papell & Prodan, 2003). The basic idea is that if goods market arbitrage enforces broad parity in prices across a sufficient range of individual goods (the law of one price), some variant of PPP is an anchor for long-run real exchange rates (Rogoff, 1996). The concept of arbitrage is also necessary for this research because the cost of a currency will be equalised, which exist due to the inefficiencies of the market.

This indictment depicts the absolute PPP, which satisfies LOOP, in contrast to relative PPP that indicates the exchange rate has to reflect the ratio of two countries (Evrensel, 2013). The equation used to calculate it:

$$\%\Delta S = \%\Delta P - \%\Delta P * \quad (1)$$

The relevance of this is that, originally, it was developed as a theory of exchange rate determination but is now primarily used to compare living standards across countries (Lafrance, 2002). Even though it is presented with various advantages, it will not be used for this paper because of the disadvantages it presents. Additionally, the theory overlooks factors other than relative price levels, such as the obstacles to trade[2] and the structure of prices in both countries, factors that may produce a permanent disparity[3] (Humphrey, 1979). Thus, this paper will focus on the exchange rates.

[2] Consisting of the terms of trade, these include tariffs, transport costs, and the like.
[3] This would be between the exchange rate and the calculated absolute PPP, the reason for this is because the PPP remains unchanged with alteration in the terms of trade caused by shifts in international demand.

An important concept to note is the Uncovered Interest Parity. When investors consider which currency to purchase, they will often look at the rates of interest on UK and US bonds alongside their expectation; the UIP states that the expected rate of depreciation of the pound against the dollar is equal to the interest rate differential between both currencies (Pilbeam, 2013). However, at times, it overestimates the currency and is not a reliable technique, therefore, it is excluded from this paper.

In order to progress, it is essential to define the key terminology of this literature. Volatility describes the rapid fluctuations in an economy, in econometrics it is used to depict the variability of the random unforeseen component of a time series and forecast aspects of future returns (Patton & Engle, 2001). Periods of volatility are often accompanied by economic uncertainty and unlike many other market parameters, which is directly observed, volatility must be estimated. Hence, it is not stochastic or conforming to a mathematical model (Kotze, 2005) and will be explored in the methodology section.

The currency crisis is an episode in which the exchange rate depreciates substantially during a short period of time (Burnside, Eichenbaum, & Rebelo, 2015) and these crises 'have been a recurrent feature of the international economy ever since gold and silver coins'. The logic is, when investors flee a currency because they fear that it may be devalued, much of the pressure of devaluation comes from 'capital flight' (Krugman P. , 2000). Consequently, currency crisis is a financial crisis which is associated with speculative attacks, it occurs when investors believe that the value of a currency is over-valued and therefore, they sell that currency in anticipation of balling and buying another currency (Pettinger, Economics Help Currency , 2017). In other words, Mexico experienced capital flight: this is when non-residents do not generate investment income receipts in the creditor country's balance of payments data (Dooley, 1988). To explain, 'in small open economies, such as Mexico, with fixed exchange rates, capital flight often is the root cause of foreign exchange market pressure. At some point countries run out of reserves and a speculative attack breaks the monetary arrangements apart' (Streiner, Seinkamp, & Westermann, 2017).

The following definitions were provided to aid in understanding operations in the foreign exchange market. Analysing the volatility that occurs in the financial sector is a platform from which this paper will be built on. Also, it is important to clarify that a depreciation in the value of a currency does not necessarily require contractionary monetary policies, macroeconomic instruments must first be utilised to support the argument that the economy is underperforming.

To examine the performance of an economy the BOP[4] is referred to, it maintains the record of the changes in a country's indebtedness to foreign powers and the fortune of its export and import Industries (Krugman O. M., 2012). The relevance of this is that it demonstrated both the demand and supply of a country's currency, allowing the country to gain favour with investors. No country can grow faster in the long-run than at a rate consistent with BOP equilibrium on the current account, unless it can finance ever-growing deficits (McCombie, 1994).

1.1.0 Aims and objectives

This paper contains two key aims in order to undergo this investigation. The first is to draw a comparison to the extent to which the exchange rate was volatile during the currency crisis compared to other periods, in the results section. Second, is to underline what lead to the transition that characterised the currency crisis and, third is to show how influenced the Mexican economy was by the US even after accepting the floating exchange rate. The following aims are met by these objectives; for the first point: data is provided on the Mexican economy during and after the currency crisis, evaluating whether the crisis impacted the economy as much as other crises. The objective for the second aim is to: expound through the literature reviews on the different causes that justify the reason to transition the exchange rate regime. Final objective to meet the third aim is: to provide data and examine the influence of US interest rates on Mexico's economy ever since the regime change.

Hence, the next section is the literature review, which is an extensive discussion of the different elements of the currency crisis; in order to investigate the extent to which the foreign exchange market was volatile it is essential to understand the denominators that led to it. The third section is divided into three parts, focusing on providing evidence of the statements constructed in the methodology. It will look at the data used for the methodology, explain how volatility will be measured and this will be applied to get the results. The fourth section will be a discussion of the methods used and the final section is the conclusion.

[4] The Balance of Payments is a record of all the financial transactions made, it includes the current, capital and financial account.

Section 2

2. Literature Review

2.1. The Mexican Peso of 1994 reasons

"Stabilising an unstable economy"

– Hyman Minsky

Firstly, the literature review will proceed in unfolding the sequence of events that lead to the crisis, from this the key contributors will be identified and punctuate what influenced the transition (the causes of the crisis) which led to volatility of the currency crisis, and different theoretical models will be used to categorise the crisis. Note that since it was a crisis, most articles and journals see the transition of the exchange rate regime as originating from a negative place, but this paper hopes to discern that there are various reasons.

Anterior to the crisis, Mexico was experiencing economic growth, during the '1950's Mexico entered an economic take-off and grew rapidly for more than 30 years. Workers were flowing into cities, manufacturing was increasing as a fraction of GDP, as agriculture declined, and education was spreading throughout the country' (Meza & Kehoe, 2012).

Yet in the 1980s the financial market was interrupted, the growth was followed by stagnation both Kehoe & Meza, (2012) argue that the crisis of 1982 prolonged to 1995 and were results of both the fiscal imbalances and of a deterioration in policies and institutions. Although 1982 can be considered the start of the crisis, it did not yet have characteristics of a currency crisis although it is characterised as a financial crisis. The currency crisis, rightly stated by Mathur (2002) stemmed from the Mexican government devaluing the Mexican peso, along with this the Mexican stock market collapsed in anticipation of a harsher economic climate in Mexico.

The crisis alerted the IMF and the world to the possibility of a systematic collapse: a crisis that could spread to many other countries and threaten the stability of the international financial system (Boughton, 2001). A plausible cause for the severity of this crisis is the remaining

fragments[5] of the 1982 default on sovereign debt, which influenced the government's decision to devalue its currency, as an attempt to diminish the trade deficit and reduce sovereign debt.

The active decision to declare default on sovereign debt is related to pressures in the currency. Flood and Garber (1984) show that severe pressure on the peg can develop even when a government has substantial foreign exchange reserves, leading to speculative attacks on the currency. Khatkhate (1998) simplifies this by stating that foreign exchange rate reserves and foreign exchange rate policies are interrelated. Hence, the effects of exchange rate volatility on the developing countries would depend on the exchange rate regimes they adopted. This will be explored further in the methodology section.

To clarify, sovereign debt is the amount of money that a country's government has borrowed, typically issued as bonds in a reserve currency (Stevenson, 2010). This priori information shows that the fragments of the debt crisis remained in the economy and progressed into another crisis. Buira (1996) on the other hand, mentions that the cause of the crisis originated in a series of unpredictable political and criminal events that changed the market sentiment towards Mexico. This explains the speculative attacks the economy faced.

Evidence of fiscal imbalances (increase in debt is an increase in credit lending), was reflected in the BOP. This leads to Whitt's (1996) analysis that fiscal imbalances existed due to lack of government intervention. Whitt (1996) argues that Mexican authorities underestimated the situation, and policy decisions (or lack thereof) were to blame, hence, causing a speculative attack. This is also supported by Krugman (1979) who states that such speculative attacks on government macroeconomic policies were inconsistent with maintaining the exchange rate peg in the long-run. However, it is important to note that Mexican policies, whether good or bad, did not alone determine the country's current account (Whitt, 1996).

Similar to Whitt (1996), Jones (1997) argues the causes and lessons from the Mexican peso crisis include the large scale of the current account deficit which had reached almost 8% of GDP in 1993-94 and the Mexican authorities commitment to a relatively fixed (in nominal terms) exchange rate, and the fact that a somewhat over-valued exchange rate was welcomed by a government strongly committed to reducing inflation rapidly (Jones, 1997). Therefore, both authors agree the Balance of Payments figures were overlooked and determination in

[5] In common papers the word fragility is referred to the small economic shocks that remain, this paper identifies with the term fragments because it is not simply the shocks of previous crisis but the inherent nature of the economy, that remains.

focusing on the inflation rate ignored the imbalance in the BoP. This argument is reasonable because the crisis became categorised as a BOP crisis and will be explained in the next section focusing on the generational models and their categorisation.

This impermanence also leads to economists questioning the overvaluation of the peso, this went far beyond the standard speculative attacks (Lustig, 1995). An overvalued exchange rate implies a country's currency is too high for the state of the economy, this tends to depress domestic demand, resulting in current account deficit in the BOP as mentioned previously (Pettinger, 2017).

In spite of this, an alternative view is provided by Carstens and Werner (1999), who argue that the transition from a fixed exchange rate to a floating exchange rate regime was forced. Thus, eliminating the blame on governmental authorities and the imbalances in the BOP. Due to 'the fragilities accumulated during the early 1990's, plus the negative external and domestic shocks faced by the economy during 1994, when under severe pressure in the foreign exchange rate market, the central bank was no longer able to defend the predetermined parity and it was decided to let the peso float (Carstens & Werner, 1999).

In addition, this paper also agrees with Lustig and Fellow (1995), who approach the situation from a failed monetary policy point of view, explaining that the problems did not arise from that year but have lingered in the economy. In 1987, the Mexican government introduced the exchange rate stabilisation plan. Lustig and Fellow's (1995) also argue that "Pacto" was successful in bringing Inflation down but as experience shows, the use of the nominal exchange rate-based stabilisation results in recurring real appreciation of the local currency because there is time for the differential between the domestic and foreign Inflation to decrease. This confirm the thesis that prior to the crisis, there were existing fragments in the economy, which lead to the currency crisis.

Subsequently, there are various reasons attributed, with detailed justification, for the crisis. This paper however, agrees with the findings of Carstens and Wener (1999), and, Lustig and Fellow (1995) which provide a historical background on the Mexican economy prior to the currency crisis, and focus on economic factors that were not completely dealt with prior to the crisis rather than Buira's argument, which considers political reasons. Although political decisions can influence the market, this paper hopes to concentrate on the re-appearance of fragments, which are the macroeconomic indicators that remained in the economy.

Both Whitt's (1996) and Jones' (1997) reasoning are sound since this crisis was the first to be categorised a BOP crisis in the 20th century. However, following the works of Hyman Minsky and that the economies are market prone this removes a limited amount of responsibility from the Mexican economies for their attempt in 'stabilising an unstable economy' with policies which focused on the present situation instead of attempting to minimise the impact of the fragments that already existed in the economy. To clarify, both Whitt and Jones focus on what the government failed to do when facing certain circumstances. The direction of this paper is in line with Carnstens and Wener's (1999) statement that the government was forced to make this decision. It is not that they did not have other options, but that the option pool was limited given the different problems. This leads to the next topic, generational models.

2.2. Generational Models

2.2.1. First generational models

As previously mentioned, to grasp the origin of the parameters used to explain generational models, Krugman (1979) introduced the first generational model which was further developed by Flood and Garber (1983), which focuses on the collapse of a fixed exchange rate regime generated by unsustainable fiscal policy.

Prior to the explanation, the impossible trinity aids in clarifying the trade-off policy makers and politicians are faced with in small open economies. The predicament is that it is impossible to have a fixed exchange rate, free capital movement and independent monetary policy. Even though capital flows are dominated by factors other than interest differentials, the connection between base money and monetary policy settings is not close to medium-term equilibrium. There remain difficult issues between capital inflows, monetary policy and exchange rate (Grenvile, 2011).

Hence, the decision policy makers have for a financial system will result in one of the factors not being met. In this case, it is a problem in the fixed exchange rate regime. The focal argument is that the deficit is financed by credit domestic expansion. Thence when the government cannot defend the exchange rate and the currency continues to depreciate, and domestic currency depends on the exchange rate, and the exchange rate that clears the domestic money market changes over time (Krugman P. , 1979).

This is related to an aforementioned concept, the UIP and PPP introduced in Flood and Garber's paper. It is assumed that the agents have perfect foresight and that the assets available to domestic residents are domestic money, domestic bonds, foreign money and foreign bonds

(Flood & Garber, Collapsing exchange rate regimes , 1983). This means the domestic money supply is the weighted average of domestic credit and foreign exchange reserves but still causes an imbalance due to unstable fiscal policy.

However, criticism of the first generational model, in particular the UIP, is that in order for it to hold it requires capital to be mobile so that investors can alter their international investment, and this is unlikely to hold consistently in the long-run. In addition, the prediction that ongoing fiscal deficits, rising debt level, or falling reserves precede the collapse of a fixed exchange rate regime, is inconsistent with the 1997 Asian currency crisis (Burnside, Eichenbaum, & Rebelo, 2015). As a result, this method will be rejected in this text.

Having said this, the character of the crisis still fits into the first model because of the key assumption that a government attempting to stop currency depreciation may find its foreign reserves exhausted and its borrowing approaching a limit. A government attempting to prevent currency appreciation may find the cost in domestic inflation unacceptable (Krugman P. , 1979). In other words, the expansion of domestic credit generates reserve losses until it is no longer pegged, leading to an upward trend in the money supply and thus, inflation. As mentioned, policy makers are conflicted with a decision because of the limitations impossible trilemma.

2.2.2. Second generational models

Second generational models focus on the government and private agents' responses in the face of speculative anticipations. Obstfeld was a pioneer in expounding the determinants that lead policy-makers to abandon a currency peg, as in Mexico. The model is based on the effects of high interest rates on the government's fiscal position (Obstfeld, 1994), and a new generation of crisis models suggest that even sustainable currency pegs may be attacked and even broken (Obstfeld, 1995). In addition, the way in which the government repays the deficit is inconsistent with the methods used to maintain the fixed exchange rate, so currency pegs can be attacked.

In contrast to first generational models, the literature is not as extensive for second generational models, but they do provide an in-depth description of speculative attacks and political agents' behaviour (it is assumed the government evaluates the (dis)advantages of keeping the exchange rate). Accordingly, the optimal strategy for the agents in an economy during a currency crisis depends on expectations.

This relates to the strategic foundation, speculation against a currency creates objective economic conditions that make liability devaluation more likely. It is also important to note that second generational models exhibit multiple equilibria, explaining Obstfeld's title, and 'self-fulfilling crises.' Regardless, the prototype of the model contains three agents, a government[6] and two private holders of domestic currency who can continue to hold or sell it to the government (Obstfeld, 1996).

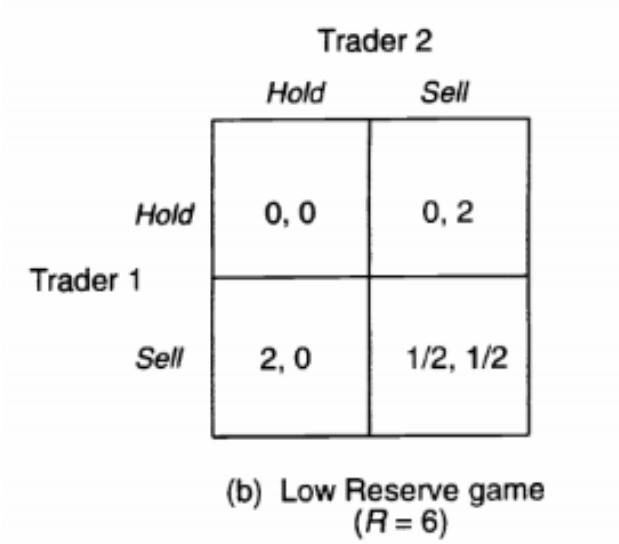

FIGURE 2 LOW RESERVES GAME (OBSTFELD, 1996)

The following paradigm (figure 2) is the Low reserves game, it shows that the government has R reserves (=6) to defend the peg, each agent has a reserve limit which reflects the differing degrees of commitment to the exchange rate's defence. To sell and take a position against the government has a cost of 1, but even if the traders were to sell their resources of 6 to the government, its reserves remain at 8 and the fixed exchange rate is maintained. In the event of giving up the peg, the government devalues by 50%, leading to a currency capital gain (because the trader would earn ½ unit of money for each unit they bought in the event of a successful attack) (Obstfeld, 1996).

Consequently, a speculating trader receives -1 regardless of the other agents' action and it is evidence that the speculation is a strictly dominated strategy, supporting that the devaluation was a purposeful strategic move that would be a greater gain for the Mexican economy.

Likewise, the Asian Currency Crisis, which began in Thailand, follows similarities to the Mexican crisis. It was initially sparked with growth and potential and, was once described in

[6] They sell foreign reserves to fix its currency's exchange rate

the World Bank's 1993 Miracle Report as a model for economic development. The irony is that a country which has always been reputed for its financial orthodoxy and macroeconomic stability appeared as the weak link in the Asian financial chain' (Lauridsen, 1998). This growth is also related to a high amount of trade such as FDI and significant investments from international banks.

Despite this, a significant ratio of this growth can be attributed to credit, the projects the government undertook were endowed by borrowing from banks, it should not be attributed to a deterioration in fundamentals, but rather to panic on the part of domestic and international investors (Corsetti, Pesenti, & Roubini, 1999). Hence, the financial mismanagement, high exchange rate and excessive spending are two of the country's leading currency crisis indicators. The excessive borrowing lead to a false sense of growth (Lai '00, 2000).

Although this paper could also draw a comparison on the Mexican Peso and Asian crisis, with similarities such as the contagion effect, and speculative attacks, there is insufficient literature to conclude an in-depth analysis. In addition, Mexico's economy faced hyperinflation during the crisis, whereas Thailand's economy did not, and it is categorised as a third generational model.

Nonetheless, the criticisms of the second generational models are that although it can provide a certain basis of the fundamentals of speculative attacks, it is not able to predict the occurrence of speculative attacks. Also, even though it examines the behaviour of agents, it fails to explore the problems in the banking and financial system.

2.2.3. Third generational models

The third generational models were developed in order to introduce the notion of moral hazard, thus assessing how agents behave in the economy. It outlines the changes in individual behaviour, prone to riskier investments, knowing that their actions will be protected a common expression used to describe this term is 'too big to fail'. 'If firms have an incentive go broke for profit at a society's expense', the economy would be better off. Bankruptcy for profit occurs most commonly when a government guarantees a firm's debt obligations (Romer & Akerlof, 1994). The role of asymmetric information[7] in the economy is crucial because often-private

[7] This is also known as information failure, it is when one party possess greater knowledge than another party does.

agents will view having a financial intermediary as an implicit government guarantee. The perceived government guaranteed bailouts are unlikely to occur if the guarantees did not exist.

Another important concept that is highlighted by Caramazza (2000) is the contagion phenomenon, which is the spreading of the crisis from one economy to another. It is due to the contagion that the crisis was named the Tequila Effect, because it triggered a decline in other currencies, due to a fall in asset prices, affecting countries such as Brazil, Argentina and Chile. This phenomenon is predicated on second-generation logic, in which abandonment of the fixed parity brings macroeconomic gains but political costs (R. Krugman, 2000) and can apply to third generational models.

The difference between first, second and third generational models is that economists were not able to predict third generational models, because there was no evidence of large fiscal deficits, and this was a key expectation in predicting a currency crisis. Although the Mexican crisis can be integrated in the second generational model because there was a collapse in the fixed exchange rate regime, it suits as a third generational model accurately.

Contagion was not a predictable factor of second generational models. Therefore, it is incorrect to categorise, solely, the Peso crisis of 1994 as a first or second generational model since it contained elements that were unexplainable. Thus, this paper states that the characteristics that were identified in the crisis contain elements and key assumptions of the first, second and third generational models.

The reason for this is that, large amounts of capital flows, either to or from one country, increase the likelihood of similar flows in other countries. Events such as devaluation of a currency or an announcement of default on sovereign debt obligations trigger an immediate and startling adverse chain reaction (Sander, 2002). This reaction is not attributed to only one theoretical model because it contains factors explained across all models. Meaning that, with the growth of knowledge comes understanding, understanding mechanisms is more important that categorising a singular event to a rigid framework.

Nonetheless, the perusal of generational models provided insight into currency crises. Volatility is present in the findings, fluctuations that occur are often triggered by the disintegration of macroeconomic models, leading to the refractory fluctuations of the Mexican peso. Consequently, this point will be developed to comprehend the mechanism of volatility in the economy.

The comprehension pre-requisite of exchange rate volatility in the foreign exchange market is to highlight the factors that traditional models often fail to identify or clarify. From the analysis thus far, the most common factors of the generational models that re-appear are: BOP, in particular when it is experiencing a deficit, affecting the fluctuations on the exchange rates domestic currency. In addition, government debt leads to a decrease in the foreign capital, as shown above, Mexico's sovereign debt was a factor that influenced speculators, inflation, uncertainty and GDP. It is difficult to consider BOP or government debt because the frequency for these variables is yearly data, and this paper focuses on monthly data. Although generational models can provide theoretical reasoning in an attempt to logically identify the patterns that lead to each currency crisis, they fail to quantify and measure the statistical value of the depreciation in a currency. This leads to the methodology section.

3. Methodology

3.1. Data sources

This section provides information obtained for the response variable and the explanatory variables to verify if the justifications provided, in the previous section, correspond to the analyses of the results conducted. In order to prove these statements, the data will first be provided. The nominal exchange rate is the dependent variable, in this case, it will be the Mexican Peso, as the focus is on the Mexican economy, so the number of Mexican pesos needed to purchase US dollars. Since the Mexican exchange rate policy was pegged to the US dollar, the US interest rate will also be collected, but the Mexican interest rate will not. The reason the Mexican interest is not collected is because the information provided commences in 2001 and there does not appear to be continuous data or credible sources. It focuses on establishing the relationship between the US and the Mexican economy through the influence of exchange rates, as there is a proportional relationship between interest rates and exchange rates- an increase in interest rates means an increase in exchange rates (Pettinger, 2019).

To commence, the nominal exchange rate, US interest rate, GDP and inflation were obtained from the Federal Reserve Economic Database. 'It is an online database consisting of hundreds of thousands of economic data time series from scores of national, international, public and private sources' (FRED, 2019). Although, there is significant mention of the BOP in the literature, it will be excluded because the frequency of the data fails to meet the requirements of this paper, as it is annual instead of monthly data.

The Uncertainty Price Index, on the other hand, was collected from the website www.policyuncertainty.com, this website 'measures the policy-related economic uncertainty, constructing an index from three types of underlying components, one component quantifies newspaper coverage of policy-related economic uncertainty' (EPU, 2019). Nicholas Bloom and Steven J. Davis unloaded this information. This relationship is depicted by Lacviello and Navaro (2018) in foreign effects of higher U.S. interest rates, who argue there is a correlation between both and countries that are open suffer as much as the US economy by its contractionary economic phases. Overall, the sources listed are reputable for economic data, which means the successive assumptions are trustworthy.

3.1.1. Evaluation of data

The main limitation presented is the data for the exchange rate begins from November 1993, therefore for all the independent variables to be analysed the same data should start from the same year. This reduces the possibility of doing an extensive review on the economy's volatility. However, it is not crucial for this paper because prior to 1994, the exchanged rate was fixed, and no volatility existed.

A limitation of the second data source is that even though the index is extracted from newspapers, this leads to questions about the association of what is considered negative terms in language, thus there is a cultural influence to determine this. Uncertainty can be both optimistic and pessimistic; for instance, one can be uncertain about the future but hope for the best. Newspapers use negative language and command verbs for profitability and though assumptions are made about people's negative approach and rational behaviour, it cannot accurately be generalised as a public response. Likewise, the data is only available for post-currency crisis, failing to provide evidence on the uncertainty during the crisis, therefore this variable will be overlooked.

3.2. Econometric Methodology

This paper presents itself with various opportunities in utilising different methods that will attain the best results in detecting the volatility, but three were selected and analysed to experiment with, GARCH models, a simplistic approach to Historical Volatility and EGARCH model. From the methods enlisted, it can be determined that a quantitative approach was chosen for this investigation. The reason for this is, the data that was provided is secondary data so it can be transformed into statistical results, which can measure the volatility. Although qualitative methods generate greater depth in understanding, it is not quantifiable (Mason,

2002). As consequence of this, theoretical reasoning was stated in the literature as an explanation for the factors that influenced the crisis.

Therefore, this paper builds on time series models, which is a univariate model, the Generalised Autoregressive Conditional Heteroscedasticity model. Univariate model refers to a time series that consists of single (scalar) observations recorded sequentially over equal time increments (Tobias & Croarkin, 2012). The benefits of using this type of model is that it measures the central tendencies of the dispersion, mean, range, variance and standard deviation, which is what this paper is most preoccupied with.

Traditionally, past researches were aware of the changes in variance, but used informal procedures to take account of this, but the ARCH model differs because it has applications to numerous and diverse areas, in particular it developed volatility tests for market efficiency and to estimate the time varying systematic risk in the context of the market model (Bera & Higins, 1993). However, the ARCH model is rejected for this paper because of its inflexibility as described by Bollerkev in the GARCH model, as a result, it is incapable of matching wide variety of patterns of financial volatility (Medeiros & Veiga, 2004). Thus, the benefit of the GARCH is that past values of the process are fed back into the present value, the conditional standard deviation can exhibit more persistent periods of high or low volatility than seen in an ARCH process (Ruppert, 2010).

Provided that the parameters of model that will be used are stated, the objectives of this section are thoroughly connected with the aims presented in the introduction section. Therefore, the first objective is to demonstrate the relationship between two variables, nominal depreciation and the US interest rate. The second objective is to detect the volatility. The third objective is the influence of the independent variables on the dependent. The following objectives ensure that an analysis is constructed on the extent to which the exchange rate market was volatile, and the variables that influenced it.

With emphasises on the role of heteroscedasticity, which is a violation of the Classical Assumption V assuming the variance term is not constant but depends on the observations (Studenmund, 2017). The assumption stems from the Gauss-Markov Theorem. Hence, an OLS estimation assumes a constant variance (homoscedasticity) in a model but is only utilised in cross-section analysis. With this came the basic assumption that the expected value of all error terms, when squared is the same at any given point (Engle R. , 2001). Thus, not useful for the question in research because it does not incorporate the variance to the model.

Heteroskedasticity can be explained in two forms- impure heteroskedasticity is caused by an error in specification, such as an omitted variable because the included explanatory variables must be absorbed by the error term; but pure heteroskedascity, on the other hand, is the only form that does not cause bias; it will be used in this paper (Studenmund, 2017). As best explained by Engle, The least square model assumes that the expected value of all error terms, when squared, is the same at any given, this assumption is homoscedasticity; when analysing the size of the errors such as volatility these are the most appropriate methods to use (Engle R. , 2001).

Moreover, the methodology of this paper is explored within the framework of both Engle (1986) and Bollerkev (1986). The reason for this is both papers expound on usage of the GARCH model, with extensive information on the conditional variance, correlation over time and stationary conditions, with Engle as a pioneer of the ARCH model. Engle's approach is focused on providing a means to answer questions that relate to volatility, concerned with the issue of heteroskedascity. It is an alternative, which is not unbiased but rather reliable. Whereas Bollerkev defines it as 'the conditional variance to change over time as a function of past errors leaving the unconditional variance constant', focusing on a flexible lag structure, whilst relating to the resemblance of autoregressive models (such as AR process from ARMA and simplistic ARCH model).

This section will first explain the autoregressive term in the model and define autocorrelation, second it will distinguish GARCH model and third introduce compulsory tests on the regression and estimation. Then, it will expand on the tequila effect, followed by the final section, which is final tests for the relationship in between the independent variables and the relationship of the dependent variable with the intendent.

3.2.1. Hypothesis

The relevance of building a hypothetical model to prove the extent to which the Mexican economy was volatile is with the sole purpose of understanding the mechanism of detecting the volatility. Thus, the main characteristics of the model and properties of the variable presented will be identified.

The autoregressive term mentioned is the conditional variance $\{\sigma_{t-j}^2\}$. The following stationary conditions ensures that the variables will be constant and the moments of the normal distribution are finite (Greene, 2012), this process can be complicated, but it will be simplified by the equation below, which shows the parameters of the conditional variance.

$$\sigma_t^2 = \alpha_0 + C(L)\sigma_T^2 + A(L)\varepsilon_t^2 \quad (2)$$

A statement can be made that C(L) and A(L), are polynomials in the lag operator of order p and q respectively, this equation is characterised as $1 - C(z) = 0$, and must lie outside the unit circle[8]. Whilst considering that $A(1) + C(1) < 1$, this assumption is stronger than the need to ensure stationarity in a higher-order autoregressive model, which depends only on C(L) (Greene, 2012). This point will be revisited when estimating the GARCH model.

Following from this, a key notion is the role of the disturbance term[9] in econometrics, an error term appears in a model to indicate the uncaptured variables. In econometrics the use of working with absolute truths is illogical/arbitrary, specific to time series data the disturbances are serially correlated, also described as autocorrelation. Due to this, time is related to the previous data point, so autocorrelation is omitted, in the dependent variable, because volatility can be persistent through time. This is categorised in the Autoregressive (1) disturbances form and represents as the following (3) , extracted from (Greene, 2012):

$$\varepsilon_t = \rho\varepsilon_{t-1} + u_t \quad (3)$$

With the given conditions that:

$$\rho = 0 \; menas \; no \; autocorrelaition; p > 0 \; means \; positive \; correlation \; (persistence)$$

And

$$COV[u_t, u_s|X] = 0 \; if \; t \neq s \quad (4)$$

Because u_t is white noise, the conditional moments equal the unconditional moments (Greene, 2012). The concept of white noise will be explained further.

Having said this, autocorrelation can also occur in the independent variables, in this case it would be a reflection of misspecification. If the evidence of the residual autocorrelation is

[8] This is a circle with a radius of 1
[9] Also referred to as the error terms

interpreted as a reflection of auto correlated true errors then the model should be re-estimated by maximum likelihood (Darnell A. C., 1994); as Bollerslev conducted a maximum likelihood estimation, this point will be expounded further in the text.

Despite this concern, testing for autocorrelation allows to estimate for ρ, introducing the popularised Durbin Watson test. Performing the following hypothesis, where the null hypothesis is 0 showing for no autocorrelation and the alternative hypothesis will be that it is greater than 0.

$$H_0: \rho = 0$$

$$H_A: \rho > 0 \tag{5}$$

The DW test was the first formal procedure developed for testing autocorrelation (Greene, 2012). The test was based on the statistic (Watson & Durbin, 1971):

$$d = \frac{\sum_{t=2}^{n}(z_t - z_{t-1})^2}{\sum_{t=1}^{n} z_t^2} = \frac{z'Az}{z\prime z} \tag{6}$$

Where $z = y - Xb$ is the vector of residuals form the fitted least squares regression and A is the matrix of the numerator (Watson & Durbin, 1971). The following equation is that each residual subtracts from each previous residual, squaring it and dividing it by squared residual, meaning they are correlated but not independent of each other. The statistic has this form because both Durbin and Watson were able to determine the exact distribution.

To describe it in brief, white noise refers to when a variable contains the following properties: identical, independent, mean-zero distribution. Some authors define white noise to include the assumption of normality, and the covariance described are in fact auto-covariance of the time series (this is the covariance between the value at time t and the value s) (Neusser, 2016), this is closely related to autocorrelation.

Although this paper decided the DW test, Bollerslev paper in the autocorrelation and partial autocorrelation[10] section utilises the Lagrange Multiplier[11] method (Bollerslev, 1986) to capture the magnitude of the autocorrelation. Contrary to Engle, who adopted the Ljung box test[12] with 15 lagged autocorrelations was used, showing that there was a degree of

[10] Partial correlation is the measure of association between two variables, while controlling or adjusting the effect of one or more additional variables (Bruce & Hendrix, 2014).

[11] The Lagrange Multiplier method which tests the effect on the first order conditions for a maximum of the likelihood of imposing the hypothesis (Breusch & Pagan, 1980)

[12] This method is used to test whether or not observations over time are random or independent (STAT, 2019)

autocorrelation in the riskiness of financial returns (Engle R. , 2001). However, this paper rejects the use of complex tests that were used in the exemplary papers to ease the simplification of the interpretation of the results, even though the LM could be used the higher order results will not be necessary for this hypothesis.

This leads to the clarification of different types of GARCH models the two pivotal GARCH models to be considered, that were mentioned in both papers but Bollerslev makes greater mention of differentiating both in contrast to Engle. The GARCH (p, q) and GARCH (1, 1) will be elaborated and the suggestive EGARCH model will be mentioned as an alternative.

3.2.2. Distinguishing GARCH models

The GARCH (p, q) process contains the classic characteristics of the ARCH model, some call the model ARCH (∞), the infinite order, due to the lag structure imposed on the coefficients, this point will be elaborated further. Bollerslev ascribes the equation in this form:

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{p} \alpha_i \epsilon_{t-i}^2 + \sum_{j=1}^{q} \beta j \sigma_{t-j}^2 \quad (7)$$

The constraints presented are, $\alpha_i \geq 0, \ \forall i$ and $\beta_j \geq 0, \ \forall j$ this was purposefully imposed to ensure the conditional variance is positive. Reading the equation, the conditional variance with respects to time is equal to alpha (the coefficient with respects to the initial alpha), added by the sum of the coefficient multiplied by the error term with respects to time minus observation i. For p = 0 this process reduces to the ARCH (q) process, and for p=q=0 ε_t is simply white noise (Bollerslev, 1986).

Therefore, it is noted that this model is a development of other Autoregressive models and Moving average models with orders (p, q), categorised in the stochastic process$\{X_t\}$, the combination of AR (p) or MA (q), allowing for every stationary process to be approximated arbitrarily well, if the process is stationary it can satisfy a linear stochastic difference equation of the form (Neusser, 2016):

$$X_t - \phi_1 x_{t-1} - \cdots - \phi_p X_{t-p} = c + Z_t + \theta_t Z_{t-q} \quad (8)$$

Let (Zn) be a sequence of i.i.d. random variables such that (Posedel, 2005):$Z_t \sim WN\ (0, \sigma^2)$, this shows that the finite variance white-noise process, which is not necessarily normally distributed but in this paper will be, Z_t describes the stochastic piece. The development of the GARCH (p, q), however, allow the expected value to be given a condition of set variables, and this was a constraint for the older autoregressive models. Therefore, the distinction is that the

mean of the random variable of interest, is described by a heteroscedastic, but otherwise ordinary, regression model; the conditional variance however evolves over time in a complicated manner (Greene, 2012) and needs to be captured.

To exemplify, the conditional variance including the previous variances: $\Psi_t = \{\varepsilon_{t-j}, \sigma^2_{t-k}; J = 1, 2, \ldots q; k = 1, 2, .., p\}$ and autoregressive moving average process with p terms in $\{\sigma^2_{t-k}\}$ and q moving average terms in the innovations$\{\varepsilon_{t-j}\}$. As stated by Engle (1986) such higher-order models are often useful when a long span of data is used, like several decades of daily data or a year of hourly data.

Overall, the (p,q) model shows that p depends on today's variance, in other words the current value is based on the immediately preceding value, whereas the q refers to the variance of today depending on the residual. Which can also be said that the value of the series depends on previous and current white noise, this directs to the GARCH (1, 1).

Garch (1,1)

Furthermore, the most common GARCH model used is the GARCH (1, 1), the way it differs from (p, q), is that yesterday's lag with only one lag, in other words it is only for one-time series. In other words, one return is squared and one return that is squared and lags one variance. It has been found that a GARCH process with few terms can perform at least as well, if not better than a model with many more terms (Darnell A. C., 1994). Consequently, allowing for a flexible lag structure. This type of volatility model formulates the conditional variance directly as a function of observables (Patton & Engle, 2000). The conditioned on an information set at time t, is denoted as Ψ_t, this is generalised so that it can include previous conditional variances (Darnell A. C., 1994):

$$V\ (\varepsilon_t|\Psi_t) = \ \sigma_t^2 \qquad (9)$$

This observation was further developed in Engle (1982) and Cragg's (1982) paper where the variance of the error term, denoted as $\square_t$, was conditional on the information available at time t (Darnell A. , 1994). To clarify the definition of lag, an instantaneous regression is when both independent and dependent variables have the same period of time; this is often not a realistic assumption to make; especially when dealing with volatility – which varies from time to time. In many cases time elapses between a change in the independent variable and the resulting

change in the dependent variable; the period between the cause and the effect is called a lag (Studenmund, 2017).

Nonetheless, this parsimonious model can be explained with the following equation:

$$\sigma_t^2 = \alpha_0 + \alpha_1 \epsilon_{t-1}^2 + \beta 1 \sigma_{t-1}^2 \quad (10)$$

This equation (10) demonstrates that the conditional variation with respects to time is equal to alpha (this is a coefficient) with respects to the initial alpha. Adding the first term of alpha, which is multiplied, by the error term squared with respects to the previous time. The first term of beta is also added to the equation, as another coefficient, and this is multiplied by the variance of the previous time. The reason for this is, the process of calculating future predicaments is influenced by previous volatility. Provided the condition that parameters α_0 , α_1 and β_1 are non-negative, the stationary condition of $\alpha + \beta < 1$ should hold to ensure weak stationary, with α_1 indicating the short-run persistency while β implies the long run persistency (Darnell A. C., 1994) To show this and explain it further the following equation will be assigned:

$$\sigma_*^2 = \alpha_0 + (\alpha_1 + \beta_1)\sigma_*^2 \quad (11)$$

$$\sigma_*^2 = \frac{\alpha_0}{(1 - \alpha_1 - \beta_1)} \quad (12)$$

Therefore, an important concept to comprehend when studying the asymptotic properties of this model is whether σ_t^2 converges to a stationarity distribution (Williams, 2011). To be clear, stationarity describes when the variance does not change over time. With the definition provided, it can be deduced that this volatility model will have a weak stationarity with the conditions that $0 < (\alpha_1 + \beta_1) < 1$ must hold for a strong process, in other words, the theorem suffices for wide-sense stationarity (Bollerslev, 1986). The reason for this is, the volatility changes over time equating to the variance changing over time, so the stationarity ensures that at each point of time we can ascertain variation and mean. From which a consensus can be drawn to say that the larger $\alpha_1 + \beta_1$, the more persistent the volatility.

Also, as mentioned another property of the GARCH model, as a characteristic of time series models is the stochastic process, this is expressed as $\{\ldots, x_{t-1}, x_t, x_{t+1,} \ldots\}$, in general for a discrete time process the random variable depends on its values (Greene, 2012). Stochastic behaviour is determined by specifying the probability density function (PDF). The concept of density in econometrics will be further explored in this text, it simply shows the probabilities

associated with specific values, the chances of any random event occurring must be anywhere from impossible to certain, and the sum of the probabilities or all events must be 1 (Pedace, 2013).

Notably, this paper deduces that the variable is Gaussian distribution for the disturbances, that is this model has the residuals that are normally distributed, which cannot accommodate fat-tailed properties commonly existing in financial time series (Feng & Shi, 2017). This is because the conditional variance of ε_t is denoted as σ_t^2, then given normality of the errors and conditional upon initial values $\{\alpha_0\}$.

3.2.3. Estimation and tests

Henceforth, an estimation of the GARCH model is the maximum likelihood condition, since Bollerslev (1986) completed this estimation it is only acceptable to explain it, as seen below with the following equation:

$$\sigma_t^2 = \alpha_0 + \sum_1^p \alpha_i \epsilon_{t-i}^2 + \sum_1^q \beta j \sigma_{t-j}^2 \quad (13)$$

$$L(\omega, \alpha, \beta) = \prod_{t=1}^T p(y_t | F_{t-1}, \alpha, \beta) \quad (14)$$

This equation is provided with the following constraints:

$$\left(\sum_1^p \alpha_u + \sum_1^1 \beta_j\right) < 1$$

The likelihood function is read as L in the equation (14) which is denoted for the natural log, where no ambiguity can arise, as a function of two parameters in this case, alpha and beta. This is equal to pi as a function of output in time t or with the parameters of alpha and beta. This condition must satisfy the constraint, which is less than 1. To elucidate, this will be shown and interpreted in the estimation output equation as the log likelihood, once all the variables are included in, the equation a regression will be done.

The maximum likelihood estimation, which will be denoted as MLE, provides a means of choosing an asymptotically efficient estimator for a parameter or a set of parameters (Greene, 2012). The aim of using this approach is to ultimately find the optimal way to fit the distribution to the data given the unknown parameters, even though Bollerslev used it, it will not be necessary for this paper.

In spite of the mention of the maximum likelihood estimation, due to the complications involved when estimating a GARCH process, it seems of interest to have a formal test for the

presence of GARCH instead of just relying on informal tools' (Bollerslev, 1986). With this statement, a test for the GARCH model is introduced. This paper will utilise both unit root test and break-point unit root test, to re-affirm the results and ensure they are reliable. The purpose of using this is to ensure that the data is stationary to avoid spurious regression, so that the data is easily interpreted, and notice if there is a GARCH effect.

Therefore, unit root test can be defined as a test which 'determines if trending data should be first differenced or regressed on deterministic functions of time to render the data stationary' (Zivot, 2019). In order to decide whether a variable is stationary or not, from the deterministic linear equation below a common rule for the test results as shown:

$$z_{t=}\ \phi Z_{t-1} + \ \varepsilon_t, \varepsilon_t \sim WN(0, \sigma^2) \tag{15}$$

This autoregressive process in the unit root test entails that if $|\phi| < 1$ it is stationary, if the results show that $|\phi| > 1$ then the first differentiation would be needed for it to become trend stationary (Zivot, 2019). As explained previously with the polynomials in the lag operator, all variables will be tested. This hypothesis uses the break-point robust test, an extension of the unit root test. Bollerslev stresses that it is necessary to test for GARCH effects first, thus showing autocorrelation. It differs from the unit root because it 'allows for a structural break in the trend process. The reason this will also be conducted is due to conventional unit root tests being biased toward a false unit root null when the data stationarity has a structural break (Perron, 1989). With the data stationary both objective two and three is met.

Conversely, the DF test is generalised in to the augmented version to accommodate the autoregressive part, whilst testing the null hypothesis. The main thrust of the literature on unit roots concentrates on whether time series are affected by transitory or permanent shocks; this can be tested by the Augmented Dickey Fuller model, which is set out as follows (Perman & Byrne, 2006):

$$\Delta y_t = \ \rho y_{t-1} + \ \sum_{j=1}^{p-1} \Upsilon y_{t-j} + \mu_t + \ u_t \tag{16}$$

This leads to the mention of model selection information criteria, and which one would best fit the data, this topic can also be related with the maximum likelihood estimation with reference to a fitting set of observations. The choice of the number of lagged coefficients as well as the degree of the polynomial is at the discretion of the modeller, some trial and error is inevitable, the charge of data mining notwithstanding (Gujarati, 1978) but the criterion models can minimise the problems.

There are two distinctive yet similar models the Bayesian Information Criteria, which was formerly introduced by Schwarz (1978), this looks at maximising the likelihood, function separately for each model. The Akaike Information Criteria, which originated with Akaike (1974) similarly, looks at selecting a model on the basis of good results. Although both appear to be similar, there are distinctive difference, existing studies show AIC is not consistent and hence does not lead to the choice of the correct model, Shibata (1976) showed through empirical evidences that AIC has the tendency to choose models that are over-parameterised (Mantalos & Javed, 2012). To depict their mathematical expressions are:

$$AIC = -2\ln L + 2k \tag{17}$$

$$BIC = -2\ln L + k\ln T \tag{18}$$

Where L is the maximised value of the likelihood function and k is the number of free parameters used in the model, and T in the BIC equation is the number of observations (Mantalos & Javed, 2012). From the equation gathered the text will use the BIC model since it appears to overcome the lack of consistency, which is present in the AIC model.

Another alternative method of calculating volatility, assuming this paper did not use the conditional volatility model, is the measurement of unconditional volatility, i.e. historical volatility. 'Historical volatility in the price of the underlying assets, but since that measurement is just historical and the volatility is varying over time it might not be a good way of measuring future volatility' (Amskold, 201). In other words, it would give the returns, this is calculated using the following equation (19). The smaller the variability the lower the standard deviation. This will also be used to check if the results are robust, this concept will be explained next. The variance with respects to time is equal to the natural log of the nominal exchange rate which is then taken away from the natural log of the exchange rate with respects to the previous time $((t-1)$, and to capture the volatility alone, this equation would simply be squared:

$$\sigma_t = \ln\left({}^{mx}/_{us_t}\right) - \ln\left({}^{mx}/_{us_{t-1}}\right) \tag{19}$$

An additional concept to grasp is volatility clustering, this describes 'periods of quiescence and turbulence tend to cluster together' (Lux & Marchesi, 1999). This implies time varying conditional variance, hence the ARCH has the property of time varying conditional and can therefore capture the volatility clustering. 'A quantitative manifestation of this is that, returns or their squares display a positive, significant and slowly decaying autocorrelation function' (Cont, 2005), this point will be highlighted in the results section.

3.2.4. Limitations of model

However, the drawbacks of the GARCH model should not be ignored, researchers beginning with Black (1976) have found negative correlation between current returns and future returns volatility. The model imposes parameter restrictions that are often isolated by estimated coefficients and interpreting whether shocks to conditional variance persist or not is difficult in GARCH models (Nelson, 1991). Thus, it fails to capture important features of the data, this means that the 'conditional variance responds asymmetrically to positive and negative residuals' (Dutta, 2014). To resolve this problem, Nelson (1991) came up with EGARCH, the leverage or asymmetric information.

In resolving the issue of symmetry the exponential GARCH model a comparison between the GARCH (1,1) model and the EGARCH (1,1) is that the exponential form allows good news and bad news to have a different impact on volatility (Ng & Engle, 1993). Despite, the benefits this would add to the analysis, it is not detrimental for the paper, because the purpose of this study is to analyse the volatility and the consensus above all and show that it was negative volatility; the main assumption of this paper is that the transition was inevitable.

Overall, the significant justification for rejecting EGARCH model is that the literature has shown that estimated conditional variance is even higher than that of the squared residual itself, this result can be interpreted as evidence against the model itself (Ng & Engle, 1993). To elucidate, the exponential growth of the conditional variance is parallel to changes in the level of shocks – making the result unreliable. In addition to this, Malmsten and Terasvirta (2004) argued that in the EGARCH model the normal errors are sufficiently flexible to capture Kurtois[13] and autocorrelation in stock returns, but suggest that the standard GARCH model can improve by replacing the normal error distribution. This is possible because increasing the kurtosis of the error distribution will help standard GARCH model to capture the kurtosis and low autocorrelations in stock return series (Ngozi, 2014).

Moreover, the GARCH model is the most appropriate model to utilise when evaluating the volatility of the returns of groups with large amounts of observations (Matei, 2009). It is the

[13] This is a statistical measure that describes distribution, as noted from above the GARCH model is normal distribution a due to the high frequency of the dependent variable, it is essential for the interpretation of the data.

most common form of assessing the volatility and can simplistically explicate on the volatility of the peso. In the words of Hansen and Lunde (2001), does anything beat a GARCH (1, 1)? In this paper, they explore whether the evolution of the volatility model has led to better forecasts of volatility and conclude that the best models do not provide a significantly better forecast than the GARCH (1, 1) model. Not to mention that this model is the fundamental basis from which other models have emerged such as TARCH, EGARCH, NGARCH, GJR-GARCH and AGARCH. Therefore, the benefits of using the algorithms of the GARCH function provides the parameters that match best with the data that will be utilised to explain the volatility of Mexico's currency crisis.

3.2.5. Contagion effect

The concept of contagion was introduced in the literature review and although this paper does not test nor examine the volatility spillovers, it is important to mention the role of contagion in this crisis due to its derived name Tequila effect. Contagion describes the heightening of co-movements of markets as well as volatility spillovers (Leung, Schiereck, & Schroeder, 2017). To elucidate, the reason this paper will not attempt to test or identify the correlation between the tequila effect in the currency crisis and neighbouring countries due to insufficient literature on this topic. Engle (1990) with Ito and Lin provided a framework that examine two types of volatility spillovers, the heat wave hypothesis, showing only country specific autocorrelation. Whereas the meteor shower is a phenomenon of intra-daily volatility spillovers frim one market to the next. The relevance of this framework is that with the heat wave it is simpler to explain the contagion from one country to another with the effects of financial liberalisation.

Dornbusch (2000), on the other hand, says that fundamental contagion such as macroeconomic shocks affect the trade status of a nation, so competitive devaluation and financial links are possible spillovers of crisis between different markets. This statement aids in comprehending how the financial sector can influence other market structures. For instance, the argument provided by Buira is that the political sector is to be blamed for poor policies, to an extent this is correct since the countries affected by the contagion were also subject to corruption. However, as mentioned in the literature review, 'stabilising an unstable economy'- fragments in the economy can provoke the creation of corrupt systems.

However, Brazil was not the only Latin American country to be affected by this, other surrounding nations include Argentina and to an extent, Chile, 'the following table consist of the residues so as to analyse their behaviour along the time' (Holanda & Correa, 2003), as shown (figure 3). Even though the table does not include Chile, there is literature explaining the "*tequila effect"* from the 1994 Mexican Peso crisis by Mathur, Gleason, Dibooglu, and Singh (2002). As mentioned, since the focal point of this paper is not the outward tequila effect, but rather the inward, further mention will not be necessary; the following mentions were only necessary because this was one of the main characteristics of the crisis, hence the title 'the tequila effect', thus it cannot be ignored.

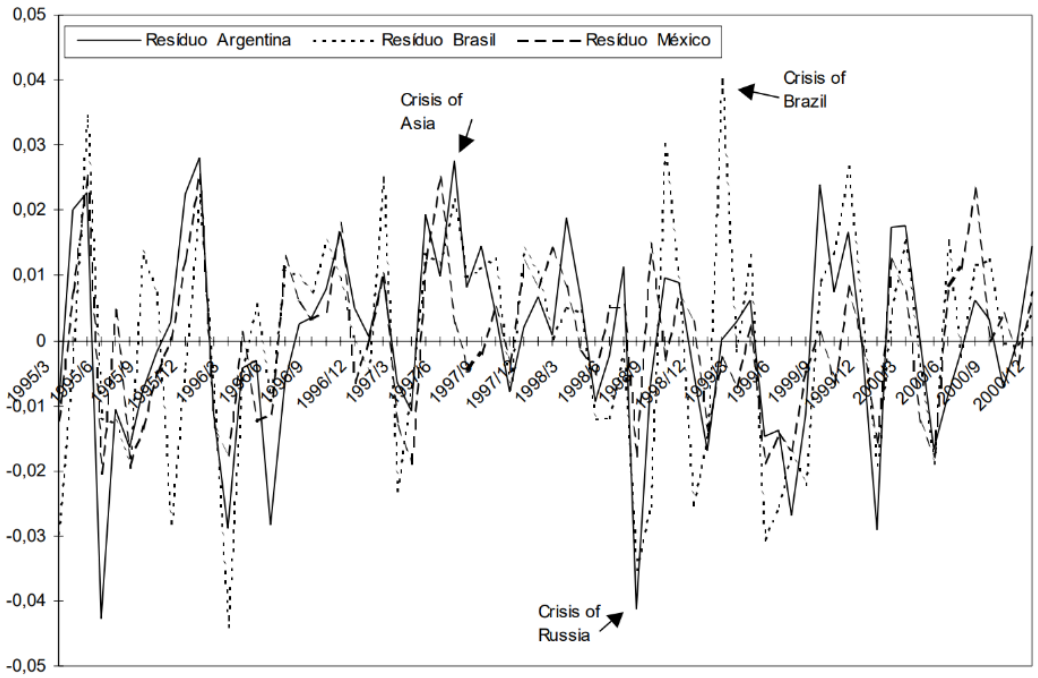

FIGURE 3: CONTAGION EFFECTS FROM THE 1994 MEXICAN PESO CRISIS (MATHUR, GLEASON, SINGH 2002)

Therefore, this paper agrees with the literature of Calvo and Reinhart (1996) on this topic because it proves that the Mexican Currency Crisis also affected other countries in Latin America; whereas Doyle does not capture enough depth or evidence of the impact on surrounding countries, hence it is rejected.

3.2.6. Independent variables

Once the volatility is detected, as was highlighted in the literature section, other independent variables will be analysed alongside the dependent variable in order to confirm if they influenced, to an extent, the exchange rate volatility. These include the US interest rate, Mexico's inflation rate and GDP. The reason these variables have been selected is due to the mentions in the literature review, thus their behaviour is singularly examined next to the volatility of exchange rates. Two tests will be performed to ensure the information is not biased.

The model that will be used to identify this is the GARCH (1, 1)-in-mean model developed by Engle, Lilien and Robins (1987), it allows the conditional variance to affect the mean. Variables that were useful in forecasting excess returns are correlated with the risk premia and lose their significance when a function of the conditional variance is included as a repressor (Lilien, Robien, & Engle, 1987).

Even though the title states that it is the ARCH model, the main element of the model is applied to the GARCH model since it focuses in correlating more than two variables, but the example used in the paper is risk premium and its conditional variance. The following equation (20) shows the GARCH in a mean model of conditional standard deviation:

$$R_i = \mu + \beta_1 \sigma_t^2 + \varepsilon_i \qquad (20)$$

Note that the limitations that were proposed above for the GARCH model still apply in this model, but the predictions need to be analysed. To analyse the strength of the predictions, R^2 will be an indicator for this. To clarify R^2 is a widely used goodness-of-fit measure whose usefulness and limitations are more or less known to the researcher (Paul, 2014). The equation for the coefficient determination is the following:

$$R^2 = \frac{ESS}{TSS} = 1 - \frac{RSS}{TSS} = 1 - \frac{\sum e_i^2}{\sum (Y_i - \bar{Y})^2} \qquad (21)$$

Lastly, since this paper will also analyse the relationship between the independent variables and the dependent variable, the correlation does not automatically imply causality; this introduces the Granger Causality test. The test assumes that the information relevant to the prediction of the respective variables is contained solely in the time series data on these variables (Gujarati, 1978). A property of the Granger Causality is that it is absent when

$f(x_t|x_{t-1}, y_{t-1})$ equals $f(x_t|x_{t-1})$. The definition states that in the conditional distribution, lagged values of y_t add no more explanation to the movements of x_t beyond that provided by lagged values of $x_t$itself (Greene, 2012).

In conclusion, of this section, the GARCH model is the most appropriate method used to detect the volatility. To ensure that the theoretical frameworks of this model are not idle, the next section will both provide and analyse the results attained from the regressions, estimations and justifications.

Section 4

4. Results

This section will use the information provided in the methodology section to meet the following objective of examining what the results show. The first part in this section interprets the data of the relationship between US interest rates and Mexican exchange rate as aforementioned, whilst looking at the depreciation of the peso. The second part includes an autocorrelation test, followed by the estimation of the GARCH (1, 1) regression, with the results analysed. The third part will compute the GARCH in-mean model, to examine the extent the other variables contributed to the volatility, and a robustness check. Last, the fourth part includes multi-collinearity and the granger causality test.

Prior to the transition, the Mexican economy was both vulnerable and susceptible to the changes that occurred in the US economy. The following figure (4) demonstrates for the early period, the simultaneous movements of the peso exchange rate with regards to the interest, the initial line appears to be joined together indicating similar movement, with minimal difference. Commencing in November however, the distance becomes wider, this supports the literature that the economy changed its policy, thus the variable was responding correctly in the economy.

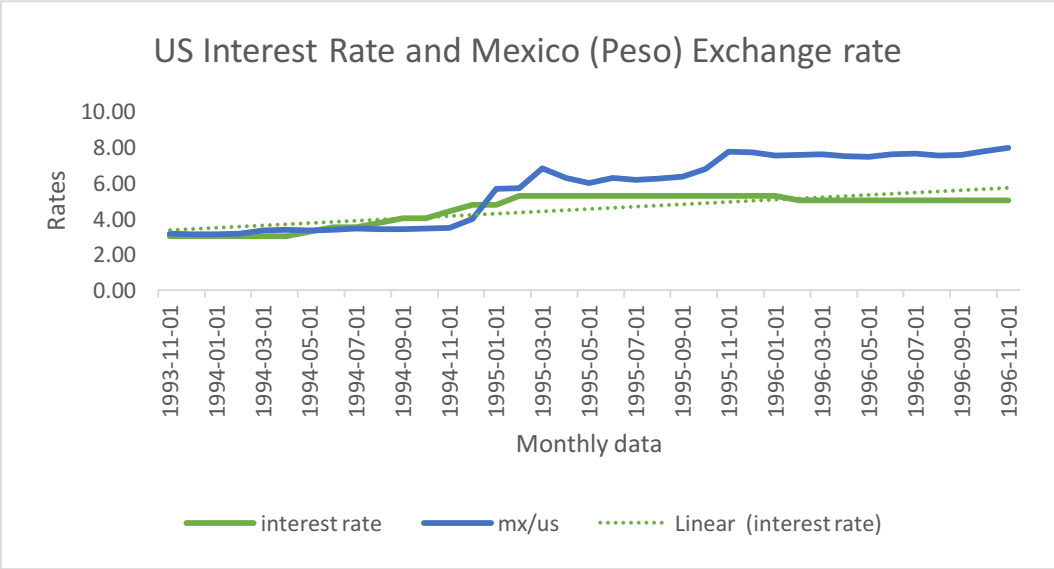

FIGURE 4 US INTEREST RATE AND MX/US EXCHANGE RATE

First, the floating exchange rate allows the peso to flow by itself, minimally affected by the changes that occur in the US dollar as the years progressed. The lending rates for Mexico took longer to return to normalcy after the collapse, in 1994-95, the real lending rates rose 70% in just four months and investment and output per capita dropped 35% and 17%, respectively, in three quarters (Ordoñez, 2012). From a theoretical perspective, it is predicted the interest rate would increase, but this paper cannot confirm this due to the insufficient data provided as explained in the data section, although it agrees with Ordonez's (2012) statement. The alternative method of the historical volatility is found in appendix 1.

In the following graph (figure 5), the peso appreciated during the currency crisis, this means there was a downward pressure on domestic prices, whilst decreasing foreign demand for domestic product. In turn, this led to the economy reaching its ultimate low, marked with a recession and a sizeable crisis followed by depreciation as stated by Mussachio (2012). The extreme highs and lows of the currency value are a representation of instability, i.e. high value losses are a result of the crisis. The appreciation weakened the currency, by decreasing demand and increasing the risk associated with investors wanting to withdraw, imports becoming expensive and causing cost-push inflation. To add to that, from figure 5, the Mexican economy was also impacted by the global financial crisis but was not as negatively affected by the crisis in comparison to the currency crisis.

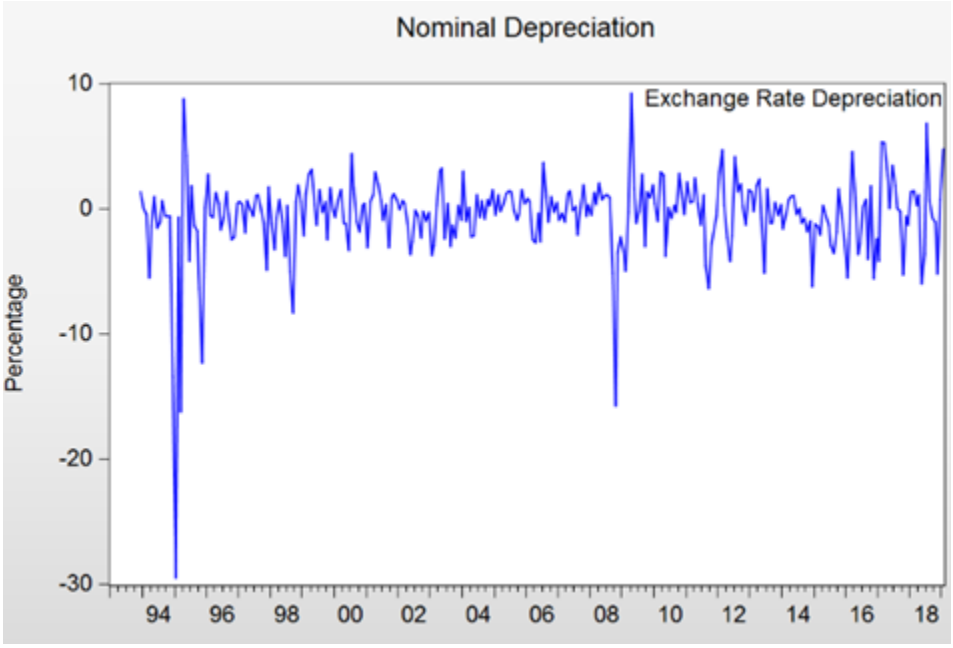

FIGURE 5 NOMINAL EXCHANGE RATE DEPRECIATION

Moreover, figure 5 exhibits volatility with clear periods of volatility clustering confirming the GARCH model is the appropriate method to be used. Prior to detecting the volatility using the GARCH model, an autocorrelation (appendix 2) and stationary test is done for all the variables (appendix 3), with the breakpoint unit root test. It appears only the dependent variable and inflation are stationary since the T statistics is lower than the p value which is <0.01, therefore they can be taken at a 10% significant level.

The GDP appears to be non-stationary, to resolve this problem it will be taken at the second level difference at 1%, similarly the US interest rate appears to be non-stationary so it can be taken as the first difference with a 5% level, and these differences will be included in the regressions to ensure stationarity.

TABLE 1 :MXUS UNIT ROOT TEST

Null Hypothesis: MXUS has a unit root

	Break Selection: Minimize Dickey-Fuller t-statistic				
	Lag Length: 0 (Automatic - based on Schwarz information criterion, maxlag=15)				
			t-Statistic		Prob.*
Augmented Dickey-Fuller test statistic			-14.489		< 0.01

Nonetheless, the estimation of the GARCH (1,1) can be seen in table (1), although the R^2 value is low, this suggests the data does not fit close to the regression line; however, the GARCH model appears to be statistically significant with a probability value < 0.05, proving the GARCH (1,1) estimation is a good fit. To justify, the p value 'can be viewed as a continuous measure of the compatibility between the data and the entire model used to compute it' (Greenland, 2016). Although an indicator may show a low result it does not mean the estimation should be ignored, the data could be indicating another relationship that was perhaps overlooked in the literature. Nonetheless, the conditional standard deviation (figure 6) confirms that the exchange rate was most volatile from 1994-1996, but with figure 5 confirms the clearer sequences of volatility clustering and the changes in exchange rate over time.

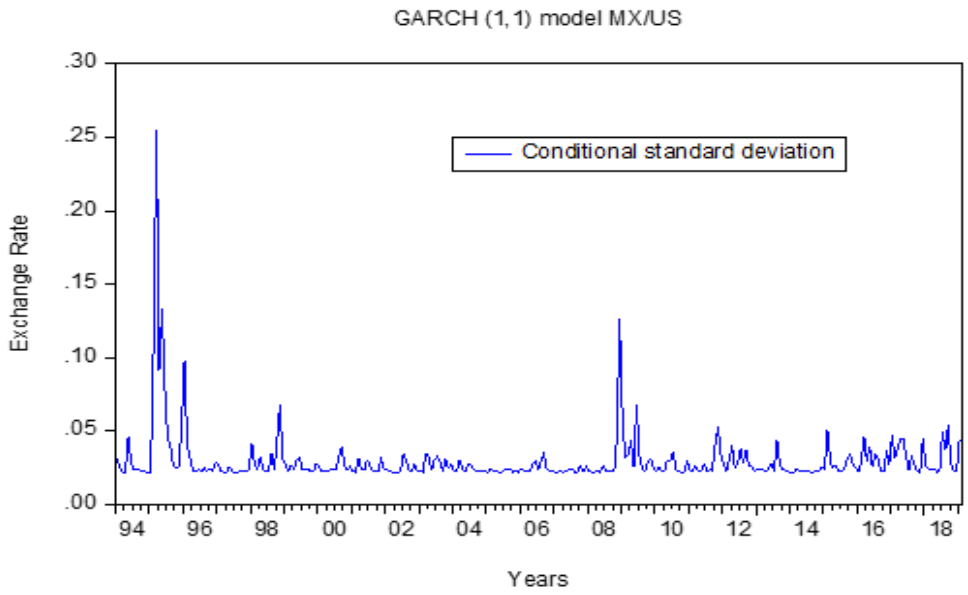

Figure 6 GARCH (1, 1) model MX/US

Nonetheless, the following table (2)[14] shows equation one using the GARCH in-mean model equation with all the independent variables, demonstrating no significance, indicating a non-existent and weak relationship between inflation, GDP and US interest rate. The second equation shows the relationship between the inflation and exchange rate, with no relationship detected; in contrast to the third relationship, which highlights the weak relationship between GDP and the exchange rate but remains insignificant. The final variables appear to also be insignificant, suggesting that the US interest rate no longer influences the Mexican exchange rate, this appears on par with the information provided in the introduction, emphasising the basic components of exchange rate regimes.

Lastly, the robustness check in the fifth equation ensures that the main analysis (which is the regression) behaves correspondingly; the results are also insignificant, meaning the conclusions hold under different assumptions, making it reliable.

[14] The squared brackets show the T statistic, this is the coefficient divided by its standard error.

TABLE 2 :GARCH IN MEAN MODEL

Eq. Name:	**EQ01**	**EQ02**	**EQ03**	**EQ04**	**EQ05**
Dep. Var:	MXUS	MXUS	MXUS	MXUS	MXUS
C	-0.007407	0.004087	-0.008748	0.002208	0.001290
	[-1.1950]	[1.5569]	[-1.5303]	[1.3668]	[0.2084]
INFLATION	0.000674	0.001984			0.001198
	[0.3814]	[1.0552]			[0.9043]
D(GDP(-2))	5.085730		5.362431		0.877744
	[1.8166]		[1.8963]		[0.3317]
D(USINTEREST)	-0.015931			-0.015932	-0.012058
	[-1.2176]			[-1.2612]	[-1.3139]
Observations:	300	302	300	300	300
R-squared:	-0.0016	0.0031	-0.0126	-0.0082	0.0059

Insignificant results should not be alarming, to gain greater clarification on the relationships presented, as was suggested in the methodology section, the Granger Causality test was done. This a unidirectional test, therefore it only shows that towards one direction of the dependent variable with regards to the independent, thus the results that are significant are discussed because of the analysis made on the p value.

TABLE 3: GRANGER CAUSALITY TEST

Pairwise Granger Causality Tests

Null Hypothesis:	Obs	F-Statistic	Prob.
INFLATION does not Granger Cause MXUS	300	0.10988	0.896
MXUS does not Granger Cause INFLATION		6.97018	0.0011
GDP does not Granger Cause MXUS	300	1.54083	0.2159
MXUS does not Granger Cause GDP		1.31110	0.2711
USINTERESTRATE does not Granger Cause MXUS	300	0.87483	0.418
MXUS does not Granger Cause USINTERESTRATE		3.04113	0.0493
GDP does not Granger Cause INFLATION	301	20.5659	4.00E-09
INFLATION does not Granger Cause GDP		0.95035	0.3878
USINTERESTRATE does not Granger Cause INFLATION	300	8.73023	0.0002
INFLATION does not Granger Cause USINTERESTRATE		0.84686	0.4298
USINTERESTRATE does not Granger Cause GDP	300	2.85337	0.0592
GDP does not Granger Cause USINTERESTRATE		3.59785	0.0286

In spite of this, table 3 indicates significance between the exchange rate granger causing inflation rate. Illustrating a relationship between both variables, the evidence for this is in the literature section where Lustig and Fellow's mention 'Pacto', a plan that aimed to stabilise the exchange rate, and proved to be successful in bringing down inflation; in 1995 May, the inflation rate was 2.23 and in September, it was 1.71[15]. The theoretical reasoning behind this is that if the value of the currency is stabilised, inflation tends to imitate this and become stable. For instance, a depreciation in the exchange rate leads to higher inflation, which makes Mexican products less competitive. If the inflation rate decreases, with respects to the US, this would lead to an increase in demand for the Mexican peso and its currency value would increase correspondingly.

In addition to this, the second significant result shows that exchange rate granger causes US interest rates, indicating a clear proportional relationship between both variables. This is best explained with the theoretical notion that the exchange rate has a proportional relationship with interest rate, since the price of dollar is taken into account this in effect alters the US interest rate accordingly. As shown in the literature in particular, the generational model emphasises the role of BOP in affecting the exchange rate and the other measures taken to stabilise macroeconomic indicators, such as interest rate. To clarify, the BOP (appendix 4) shows a deficit, this means that a country as a whole is spending more than it is earning and is therefore reducing net claims on the rest of the world and increasing its indebtedness.

This leads to an example particular to the US economy, the increase in debt during the 1980s.[16] There was a substantial rise in interest rates due to a rapid rise in the US budget deficit (Pilbeam, 2013), and this budget deficit remains. Therefore, the budget deficit, which causes a depreciation in exchange rate, lead to a rise in interest rate, and this rise contributed to a rapid real appreciation of the US dollar (Pilbeam, 2013).

Furthermore, the third result relates to the interest rate causing inflation, this relationship was not stated in this manner in the literature review. It is important to highlight that interest rate and inflation have a direct relationship as variables and as mentioned previously, the interest rate can alter the demand for money, as the demand for money is proportional to the price level (Krugman & Wells, 2013). However, the granger cause of the US interest rate impact on the

[15] The following figures are the natural log of the inflation rate shown its elasticity in order to, relate with demand.

[16] In the literature it states that Mexico defaulted on its sovereign debt, but the debt crisis also impacted Argentina, Brazil and Venezuela

Mexican inflation rate is interpreted through the work of Lacaviello and Navarro (2018), in which they analyse the foreign effects of higher US interest rates. It showed with their panel data (appendix 5) that the tightening of the 1980s were followed by weaker growth in many emerging market economies, but the situation was reversed with the higher interest rates of the mid-1990s (Lacoviello & Navarro, 2018). This reversal for the Mexican economy was potentially due to the 'Pacto' that was mentioned above, that left them unaffected by the US interest rate.

Lastly, the final results show a bidirectional significance of the US interest rate and the Mexican GDP. Providing a theoretical background for both variables, the inverse relationship of lower interest rates leads to higher consumption, which in turn means an increase in GDP (Krugman & Wells, 2013). As it was stated above, the US interest rates can have an impact on developing countries' growth rate. With GDP as an indicator of an economy's health, an open economy includes the net exports, Mexico is the US is third trading partner[17] (OEC, 2019), indicating a strong economic integration between both which affects exchange rate integration too.

This economic integration exhibits a certain peculiarity that was detected by Arteta, Kamin and Vitanza (2009) puzzling peso, since the crisis, some observers have noted an unusual aspect of the peso's behaviour. This involves periods when the U.S. dollar has risen (fallen) against other major currencies such as the euro, the peso has risen (fallen) against the dollar. This pattern implies that when the dollar rises (falls) against other major currencies, the peso rises (falls) against those other currencies by an even greater extent (Arteta, Kamin, & Vitanza, June 2009). The authors rationalize this peculiarity due to proximity, in this case, it would be distance and historical ties. Hence, both nations benefit from one another but remain competitive in terms of their trade in order to minimize trade deficit. In the past, the implications of a budget deficit for the US has led to a decrease in exports, the high interest rates contribute to a rapid real appreciation of the US dollar which in turn meant an increase in the real value of the developing countries debt-service repayment (Pilbeam, 2013).

Although more could be indulged in this particular result, it is not the focus of this paper and more attention will not be devoted to it, instead the evidence presented simply aids in reaching a consensus of the result. This leads to the next section, which is the discussion.

[17] The products they trade are: petroleum and manufacturing

4.1. Discussion

From the results attained in the previous section, the value of the R^2 appears to be low, this however is not alarming to the investigation because, with a time series model the focal point is often the predicaments of future values and not how well it fits past values. For instance, when answering this thesis question on the extent of the volatility, this paper analysed the variables that influenced the exchange rate towards its peaks and compared it to other time periods following from the currency crisis. As a consequence of this, the constraints faced when estimating the regression, in regard to the sole interpretation of R^2, is that the reflection is on fitting past values. An attempt to decrease this problem would be to add repressors to the model in order to obtain a perfect fit. However, this paper rejected this ideology because it would provide abysmal predictions outside the sample that may granger-cause but not correlate.

It appears that none of the independent variables granger cause the dependent variable, this confirms that they had little or no impact on the extent to which the Mexican exchange rate was volatile during the currency crisis. This differs considerably from the actual notion of causality, the principle of, or relationship between, cause and effect. This notion stems from the ideology that nothing can occur without being caused by something. Confirming the argument established in this thesis, because from the literature review these variables were referred to either directly or indirectly.

Nevertheless, since the Mexican economy is inherently volatile, a suggested method to improve the detection of the volatility in the value of the currency is a multivariate model. This involves two or more variables to be analysed at the same time, therefore the volatility of the exchange rate could also be captured with the inflation rate. A suggestion is the development in Engle's work (2000), Dynamic Conditional Correlation, 'these have the flexibility of univariate GARCH models coupled with parsimonious parametric models for the correlation' (Engle R. F., 2002). 'These methods have clear computational advantages over multivariate GARCH models in that the number of parameters to be estimated in the correlation process is independent of the number of series to be correlated' (Engle R. F., 2002).

Therefore, a GARCH DCC model permits that the conditional correlations are satisfied in this constraint for the past information, this means it would produce a better R^2 value. The issue with the univariate model lies in the time series specification framework providing useful information, but it can only capture one variable at a time unlike the DCC model, which can also be symmetric.

Section 5

5. Conclusion

In conclusion of this thesis, from the above analysis it is necessary to conclude that there is no significant impact of the economic causes of the peso crisis that is US interest rate, inflation and GDP, on the Mexican exchange rate. Qualitative methods alone cannot provide the justification needed to answer the question that was presented in this thesis; therefore, the theoretical background served the purpose of identifying the root of the problems that occurred in Mexico, but from the results it is deduced that the exchange rate has a greater impact on the economic instruments mentioned, and not that the independent variables impact the dependent.

Although, the tests conducted showed no obvious relationship between the variables selected with the dependent variable, this does not eliminate the possibility of a correlation. It is important to state that even though the following variables did not have the impact in the direction that was expected, it did not fail to show how variables in an economy are intertwined. To clarify, the decision made by the central bank in the short term interrupted the behaviour of the macroeconomic variables, but in the long-run they appear to be less volatility, with contrasts to the time period of the crisis.

Moreover, the decision of transitioning from a fixed exchange rate regime to a floating one allowed the economy to freely float without government intervention and this led to better absorption of crisis, this was obvious when the global financial crisis occurred. This also meets the first aim of comparing volatility to other periods is that the economy appeared more independent of the US economy in contrast to the previous years.

In the discussion section, the second aim was justified due to the lack of qualitative evidence showing what sparked the currency crisis, but the theoretical argument was fulfilled and replaced the quantitative methods necessary to undergo this investigation. Imitating the tone of Carstens and Werner (1999), the government was persuaded into making this decision and it was the best decision that could be made for the economy; another concept introduced to prove this is the impossible trilemma.

Nonetheless, the final aim introduced is to demonstrate the relationship between the Mexican economy and US briefly. From the findings in this paper, further research would need to be

conducted in order to rationalise the relationship by focusing on both economies simultaneously. Although this paper utilised the academic framework of international finance, it is not limited to this. Other academic branches can be touched upon to expand on some of the findings in this paper, such as international trade and, in particular, economic growth since there are certain traits and exposure the Mexican economy had due to being a developing nation.

Overall, the extent to which the causes highlighted in the literature review and selected in the data section lead to the Mexican exchange rate volatility, are attributed to the inherent vulnerability which increases the level of risk economy, this was described as fragments in this paper. To conclude, the causes are correlated with one another, but it cannot be said that the variables presented in this thesis are the reason for the transition, which in turn caused the volatility in the exchange rate. As the results show, the reason for the transition is how much other variables also forced this change, which does not appear to be significant in this paper.

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Appendices

Appendix 1 – historical volatility (for hand print need to print out the copy on excel)

Month	MX/US Returns	Historical volatility
1993M11		
1993M12	-0.013263006	0.000175907
1994M01	-0.000160873	2.58801E-08
1994M02	0.004494678	2.02021E-05
1994M03	0.056300279	0.003169721
1994M04	0.014101044	0.000198839
1994M05	-0.009840768	9.68407E-05
1994M06	0.015081527	0.000227452
1994M07	0.010634941	0.000113102
1994M08	-0.006396956	4.0921E-05
1994M09	0.006132456	3.7607E-05
1994M10	0.005569086	3.10147E-05
1994M11	0.006206585	3.85217E-05
1994M12	0.143776481	0.020671676
1995M01	0.349998282	0.122498797
1995M02	0.006608732	4.36753E-05
1995M03	0.17695308	0.031312393
1995M04	-0.084398993	0.00712319
1995M05	-0.041702074	0.001739063
1995M06	0.042424299	0.001799821
1995M07	-0.017968917	0.000322882
1995M08	0.013418229	0.000180049
1995M09	0.017889851	0.000320047
1995M10	0.065634221	0.004307851
1995M11	0.131557674	0.017307422
1995M12	-0.000858224	7.36548E-07
1996M01	-0.027217588	0.000740797
1996M02	0.005027046	2.52712E-05
1996M03	0.00661521	4.3761E-05
1996M04	-0.013140584	0.000172675
1996M05	-0.004374026	1.91321E-05

To note that the MXUS Returns presented was extracted from its natural log form

Appendix 2 – autocorrelation results of the dependent variable, showing weak autocorrelation

Sample: 1993M01 2019M01
Included observations: 302

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.223	0.223	15.225	0.000
		2	0.090	0.042	17.696	0.000
		3	-0.030	-0.062	17.975	0.000
		4	-0.080	-0.068	19.948	0.001
		5	-0.004	0.036	19.954	0.001
		6	-0.075	-0.076	21.682	0.001
		7	-0.018	0.004	21.786	0.003
		8	0.086	0.102	24.079	0.002
		9	0.087	0.050	26.475	0.002
		10	0.121	0.070	31.041	0.001
		11	0.071	0.034	32.654	0.001
		12	0.008	-0.014	32.675	0.001
		13	-0.070	-0.073	34.216	0.001
		14	-0.062	-0.009	35.446	0.001
		15	-0.019	0.020	35.565	0.002
		16	0.031	0.038	35.880	0.003
		17	0.000	-0.028	35.880	0.005
		18	-0.025	-0.046	36.085	0.007
		19	-0.013	-0.021	36.136	0.010
		20	-0.004	-0.010	36.142	0.015
		21	0.030	0.033	36.431	0.020
		22	-0.006	-0.005	36.443	0.027
		23	0.028	0.046	36.709	0.035
		24	0.032	0.024	37.058	0.043
		25	-0.038	-0.060	37.533	0.051
		26	-0.050	-0.048	38.356	0.056
		27	-0.015	0.025	38.427	0.071
		28	-0.023	-0.009	38.600	0.088
		29	-0.048	-0.045	39.374	0.095
		30	-0.052	-0.026	40.302	0.099
		31	-0.013	-0.007	40.357	0.121
		32	0.027	0.005	40.610	0.141
		33	0.040	0.024	41.163	0.156
		34	0.114	0.119	45.643	0.088
		35	0.042	0.002	46.256	0.097
		36	0.008	-0.005	46.279	0.117

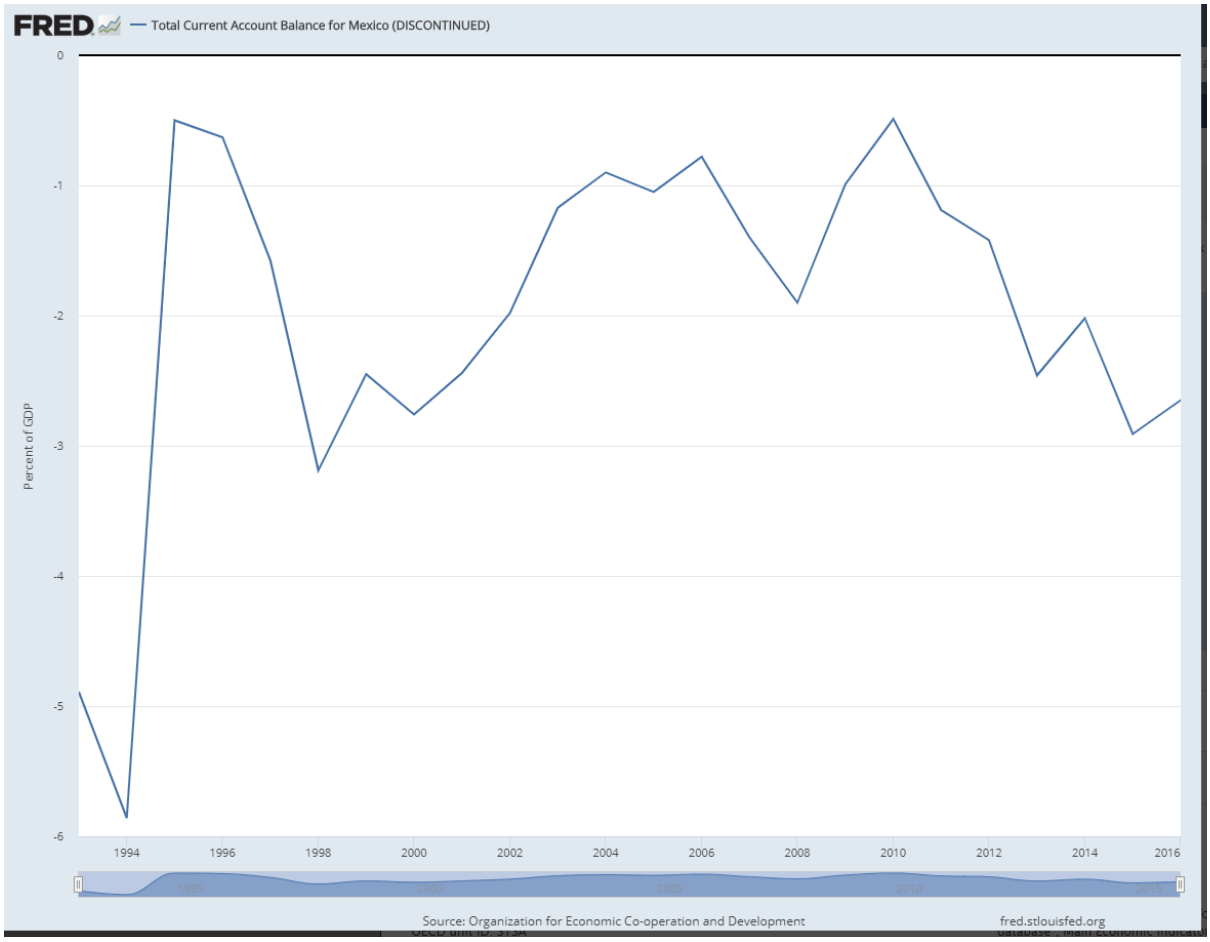
Appendix 3 – Unit root tests for all variables

Null Hypothesis: INFLATION has a unit root					
Break Selection: Minimize Dickey-Fuller t-statistic					
Lag Length: 0 (Automatic - based on Schwarz information criterion, max=15)					
			t-Statistic	Prob.*	
Augmented Dickey-Fuller test statistic			-11.89545	< 0.01	

Null Hypothesis: D(GDP,2) has a unit root				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-4.484858	0.0451

Null Hypothesis: D(USINTERESTRATE) has a unit root				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-13.6324	< 0.01

Appendix 4 – show the BOP for Mexico



Appendix 5 – simply the panel data taken from that reference

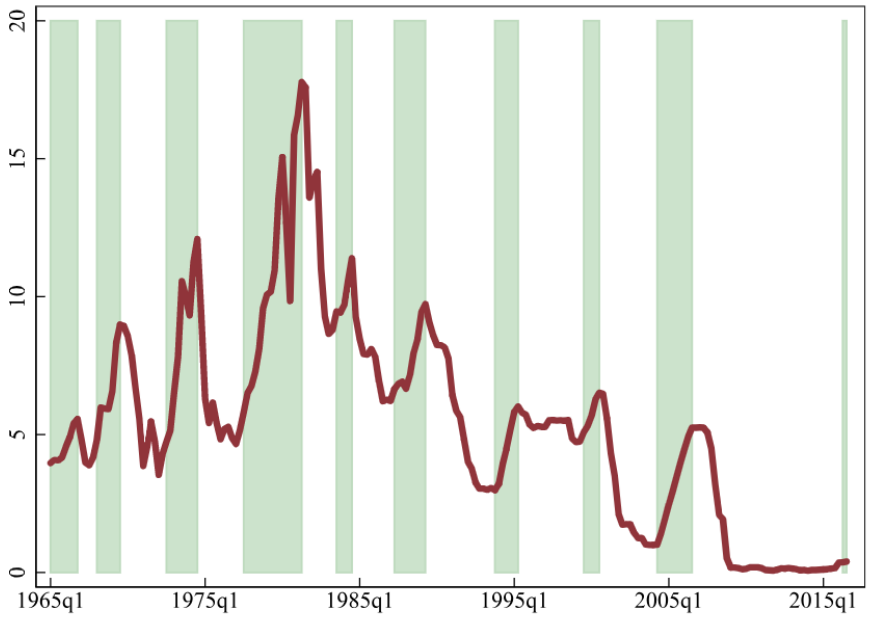


Fig. 1. The federal funds rate (FFR) from 1965:Q1 through 2016:Q2. **Note**: The shaded areas denotes periods of interest rate tightenings. A quarter t contains a tightening if it satisfies any of the following criteria: (1) the FFR does not fall in t and rises by at least 20 and 40 basis points in quarters $t-1$ and $t-2$, respectively; (2) the FFR does not fall by more than 30, 20, and 10 basis points in $t, t-1$, and $t-2$, does not fall in $t+1$, and rises by at least 20 and 30 basis points in $t+2$ and $t+3$; (3) the FFR rises by at least 100 and 200 basis points in $t-3$ and $t-2$, and rises by at least 100 basis points in $t+2$.

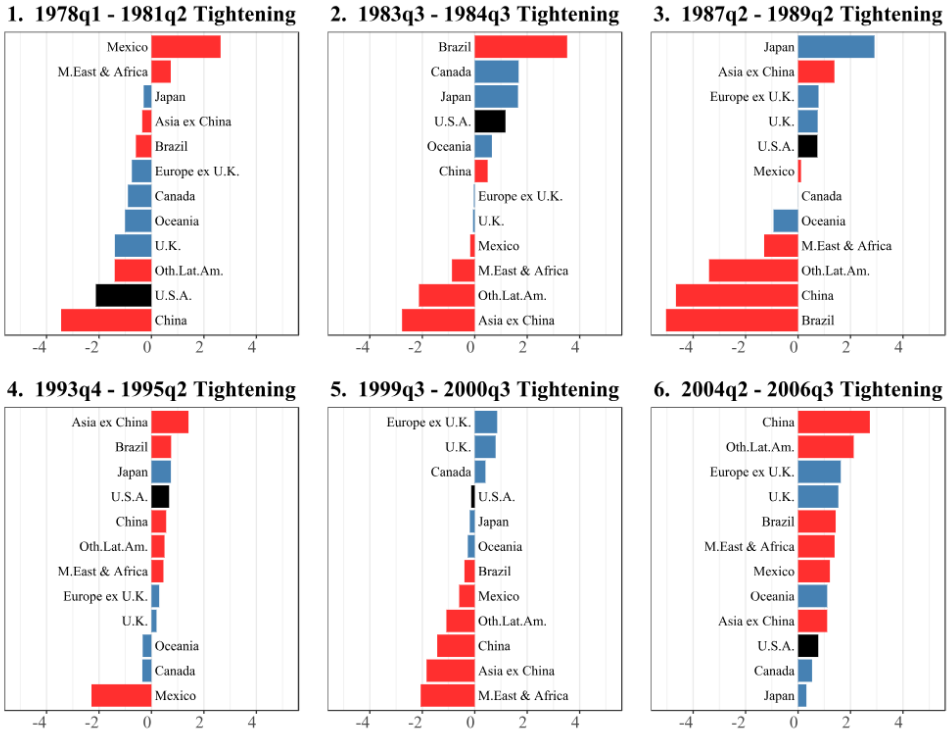


Fig. 2. Foreign GDP growth relative to forecast after U.S. interest rate increases. **Note**: Annual GDP growth surprises (actual minus forecast) in each region relative to ARIMA model in the aftermath of selected U.S. monetary policy tightenings. The bars measure average growth surprises from the beginning of each episode until one year after its end.