Emerging Market Economies and the Impossible Trinity

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Abstract

This project re-examines the question of monetary independence in emerging markets using a novel econometric approach. Whether a country can conduct independent monetary policy is central to the choice of the optimal exchange rate regime and other financial regulatory policies. As implied by the Mundell-Fleming model, the trilemma describes the choice between two out of the three macroeconomic policy options: free capital mobility, monetary autonomy, or fixed exchange rates. The purpose of this project is to test whether flexible exchange rate regimes are able to insulate the domestic economy from monetary policy decisions in base countries such as the U.S. I empirically estimate the relationship between the interest rates for countries with a peg as well as countries with floating exchange rate regimes and the interest rate of the base country. Global shocks to commodity and asset prices and coordinated responses of central banks to these shocks may lead to base rates being endogenous. Yet, a key shortcoming of the existing literature is a failure to account for such endogenous movements in the base interest rate. Previous period spreads between the federal funds futures rate and the target rate are used to predict changes in U.S interest rates. I use a New Keynesian model to identify sources of endogeneity as well as to establish the validity of the instrumental variable approach. The theoretical analysis shows that instrumental variable methods can address bias in pegging countries, but are not sufficient to address omitted variable bias for non-pegging countries without adding additional endogenous controls to the empirical specification. The empirical results support the findings from the theoretical analysis, IV results for pegging countries result in coefficient estimates close to one while results for non-pegging countries show coefficients much smaller than one.

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1 Introduction

Globalization and the integration of commodity and asset markets around the world introduced an unfamiliar set of policy trade-offs encountered by both advanced and emerging market economies. At the time, the Mundell-Fleming model was a novel theory that incorporated international finance into the original IS-LM model. The impossible trinity, also known as the trilemma, was a term coined in conjunction with the development of this macroeconomic model incorporating open economies. The term trilemma in international finance and macroeconomics, describes the prediction of the Mundell-Fleming model that a country can only have two out of three policy features: free capital mobility, monetary autonomy and fixed exchange rates.

Free capital mobility in a nation allows its residents to invest abroad while inviting foreign investors to import resources into the country. Monetary autonomy allows policy makers to increase the money supply or decrease interest rates when the economy is facing a recession, or do the opposite when facing an economic boom. Fixed exchange rates may provide stability in the domestic economy. Rapid exchange rate fluctuations can be a source of economic volatility, induced by price fluctuations in imported goods which are often inputs to domestic production. This increases uncertainty for investors and consumers. The prevalence of pegged exchange rates around the world or the introduction of the Euro are testimony to the desirability of stable foreign exchange markets. The cost of stable exchange rates on the other hand is the possible loss of monetary autonomy.

The purpose of this paper is to test empirically the extent to which countries with flexible exchange rate regimes can utilize monetary policy to steer the economy, by setting their own interest rates, in the face of international or domestic business cycle shocks. The fundamental arbitrage condition that underlies the trilemma, and is at the heart of the Mundell-Fleming model, is the Uncovered Interest Parity (UIP) relationship. The UIP relationship essentially describes an investor's indifference between investing in either a foreign or the domestic economy. Frankel, Schmukler and Serven (2004), Shambaugh (2004), Klein and Shambaugh (2013) and Obstfeld (2015) used implications of the UIP to test monetary policy independence by empirically relating domestic interest rate movements to interest rate movements in a base country, such as the U.S. A key shortcoming of the existing literature is an inability to disentangle exogenous from endogenous movements in the base country interest rate. A specific example of endogeneity not accounted for in the current literature is the possibility of common shocks that affect both the domestic and base countries and that generate interest rate or monetary policy responses. Examples of global shocks are commodity price shocks, such as oil price shocks. If the domestic and base country follow a price stability rule, both countries react to price shocks. In other words, there is a direct effect on the base country's interest rate as well as the domestic country's interest rate.

This project uses instrumental variables to disentangle endogenous from exogenous movements in the base country interest rate. The difference in the federal funds futures rate and target rate in the month prior is used as the instrument for the change in the U.S. policy rate. The federal funds futures rate is an ideal predictor of monetary policy because it represents the market opinion of where the target rate will be in the future. A more detailed description of the predictive power, and reasons for using this specific variable as an instrument are discussed in Section 4.1.

In the remainder of the paper, I first focus on providing a review of the literature encompassing the trilemma, followed by an explanation of the theoretical aspects of the IS-LM-FX model as well as an analysis of a New Keynesian model. In Section 5, I describe the methods and data collected from the IMF IFS database, then I discuss the results in Section 6.1. Conclusions with directions for future work are offered at the end.

2 Literature Review

First developed in 1937 by John Hicks, the IS-LM model is a macroeconomic model that demonstrates how the goods market interacts with the money market. The equilibrium of these two markets determines the short-run relationship between the interest rate and output. The traditional form of the IS-LM model assumes a closed economy. However, as trade became more prominent, a natural extension of the model was to allow for an open economy. In 1964, Robert Mundell and Marcus Fleming developed what later become known as the Mundell-Fleming model. With trade and foreign exchange (FX) the original IS-LM model is extended to account for an open economy. The foreign exchange market equilibrium condition equates the expected domestic return and the expected foreign return in a relationship known as the uncovered interest parity condition. An important implication of the Mundell-Fleming model is that countries face the policy trilemma when choosing between monetary policy autonomy, exchange rate regimes and capital market openness.

The monetary trilemma in Mundell (1963)'s work is obtained in a model in the tradition of Keynesian analysis and lacks a rigorous micro-foundation. Backus and Kehoe (1989) demonstrate in a general equilibrium model that monetary authorities are not able to maintain a fixed exchange rate while at the same time employing monetary policy autonomy and free capital mobility: arbitrage by international investors renders sterilized exchange rate interventions ineffective. Following the definition of the trilemma, Backus and Kehoe (1989) demonstrate that the only way policy makers are able to control the exchange rate is to either forgo monetary autonomy or implement capital controls. They show that the driving force behind the ineffectiveness of sterilized FX interventions is a fundamental no-arbitrage condition underlying the UIP. This is a powerful result that suggests that the trilemma is a robust feature of international asset markets. On the other hand, Rey (2013) argues that the trilemma is in fact a dilemma, concluding that despite the presence of a floating exchange rate regime, local economies are susceptible to international financial cycles. She advocates that there are certain international factors driving global financial cycles, which hinder a nation's ability to employ monetary independence even under floating exchange rates. However, Obstfeld (2015) notes that Rey's findings should not be interpreted as a complete absence of the trilemma. He states that "floating exchange rates can be helpful in the face of some economic shocks but almost never provide full insulation against disturbances from abroad. Rather, they provide an expanded choice menu for policy-makers"[1]. Thus, the debate on whether monetary policy regimes can insulate the domestic economy from foreign policy shocks continues to be relevant.

On the other end of the spectrum, some authors suggest alternative theories that claim it is possible to manage exchange rates even in the presence of free capital mobility and monetary autonomy. One of these theories is the portfolio balance approach. Recently, Magud, Reinhart and Rogoff (2011) or Blanchard, Adler and Carvalho Filho (2015), argued that investors favor a blend of both foreign and domestic assets in their portfolio. One basic implication of the portfolio balance approach is that the UIP does not hold in its pure form, thus arbitrage opportunities are present between the domestic and foreign country. The nominal exchange rate then is determined by the supply and demand of assets in both countries, giving the central bank leverage to influence the exchange rate through open market purchases.

In an influential paper, Shambaugh (2004) tests for monetary policy independence. His empirical specification is centered around the UIP which plays a key role in determining the effectiveness of monetary policy under various exchange rate regimes. He considers a large panel of countries and finds that countries with fixed exchange rate regimes are more susceptible to foreign interest rate shocks than countries with floating exchange rate regimes. Shambaugh utilizes an Ordinary Least Square (OLS) estimator to test the effects of changes in the base country's interest rates on changes in the domestic country's interest rates. Based on these findings, Shambaugh concludes that countries classified as pegging are more responsive to changes in the base country's interest rates than non-pegging countries. One considerable assumption made in his paper is that the base country's interest rate is exogenous to the domestic interest rate.

Preceding Shambaugh (2004), Frankel, Schmukler and Serven (2002), conduct a similar study, however, use interest rate data at a monthly frequency as opposed to the yearly frequency used by Shambaugh. Countries used in the regression by Frankel, et al. are compared with only U.S interest rates. Shambaugh uses a medley of base countries, which are determined by three factors; historical importance for the domestic country, the nearby dominant economy to which other currencies are pegged, or the U.S dollar as the default. Frankel et al. use the same basic OLS estimator for initially testing short run effects, however later they include a set of control variables, the difference between the domestic and foreign inflation rates, to test the effects in the long run. According to Frankel et al. "in the long run, the ability of countries to set

[1]Obstfeld (2015), p.20.

nominal rates (if it exists) might be the result of the ability to choose a different long-run inflation rate and/or of imperfect capital mobility (p.705)." However, they find that including the inflation differential does not significantly alter the empirical estimates. Another contribution by Frankel et al. is the division of the sample by decade. Since financial integration increased between the 1970s into the late 1990s, dividing the sample allows them to visualize the impact of capital mobility on monetary independence over time. After partitioning the data, Frankel et al. find that during the 1990s, despite the differences in exchange rate regimes, all domestic interest rates show a high sensitivity to foreign interest rates. Frankel et al. do acknowledge that they have not examined the effects of alternate channels through which international interest rates pass-through to domestic interest rates, such as common shocks.

Expanding on the work of Shambaugh (2004), Klein and Shambaugh (2013) address the question of whether intermediate policies can lead to full monetary policy autonomy. The results from Klein and Shambaugh (2013) confirm the fundamental beliefs of the Mundell-Fleming model, free capital mobility coupled with the selection of a floating exchange rate regime grant a country with the power of monetary autonomy. Moreover, they contend that partial capital controls will not enable a country to have greater monetary control, as compared to open capital accounts. On the other hand, limited exchange rate flexibility can lead to limited monetary autonomy. Klein and Shambaugh discuss 'middle ground policies' for capital control and exchange rate regimes. These middle ground policies can consists of "opening and closing financial accounts, or flipping back and forth across exchange rate regime." These policies have become increasingly important in managing exchange rate regimes. Many countries are beginning to move towards a 'soft-peg', which allows the exchange rate to fluctuate within a wider band, as opposed to a 'hard-peg.' The middle ground policies in capital controls have become of recent policy interest since the onset of many financial crises world wide. The Klein and Shambaugh paper postulates that capital controls may be useful under specific conditions. For example, if targeted capital controls are used in a flexible manner they could serve as a mechanism to lessen the severity of financial shocks. Also, countries that employ a fixed exchange rate regime could substitute monetary autonomy with limited capital controls to provide the country with authority over policy decisions. The methodology of their paper focuses on a modified version of the model used in Shambaugh (2004). Klein and Shambaugh include a variable representing the "tax domestic residents pay on borrowing from abroad (pg.4)." They also include the sum of the percent change in the expected exchange rate, the risk premium, the tax component and the unobserved effects. Klein and Shambaugh (2013) also hypothesize that there should be a one-to-one relationship between changes in the base interest rate and domestic interest rate soft pegs.

In more recent work, Obstfeld (2015) tests if countries that employ a floating exchange rate regime will be better able to insulate their economy from financial shocks. In his paper, Obstfeld established a middle ground between two extreme views of the trilemma. He argues that open emerging market economies are able to gain limited monetary independence. By closely following the methodology used in Shambaugh (2004), his regression equation links the domestic country's nominal interest rate to that of the base country. Shambaugh (2004) exclusively analyzes short-term interest rates, while Obstfeld examines both short-term and long-term interest rates. Under a pegged regime, the relation between the domestic country's interest rate and the base country interest rate will be one-to-one. On the other hand, Obstfeld argues that if there is flexibility in the exchange rate the relationship will be less than one. In that case, the changes in the base country interest rate have less of an effect on the changes in the home country interest rates. Obstfeld notes a few concerns with this OLS regression. His main regression contains a vector of covariates that includes domestic variables that may effect the domestic country's interest rate. If the peg is non-credible, some of the covariates may affect the changes in the domestic interest rate. In this case, we may see a larger than one relationship between the changes in the base interest rate and domestic interest rate, which will create an amplified response. Another prominent issue are unobserved global shocks that are not captured by regression controls. According to Obstfeld, "shifts in global risk tolerance or global liquidity might simultaneously move the base and domestic rates in the same directions," creating an upward bias in the OLS estimate for the coefficient of the change in domestic interest rates, even though the country could be under monetary independence. This upward bias would indicate "positive transmission of the financial cycle, not of monetary policy." However, these claims are not inline with the empirical evidence shown in Section 6.1. Through the theoretical analysis, discussed in later sections, and supported by the empirical evidence reported in Section 6.1, I show that there are multiple channels of endogenous responses which are able to generate a downward bias in the OLS parameter estimate for non-pegging countries. Obstfeld concludes that countries adopting a flexible exchange rate regime are more capable of insulating the economy from financial shocks as compared to countries with a fixed exchange rate regime. Frankel et al. also find that under a "single-country dynamic," countries with floating exchange rate regimes see a "higher speed of adjustment of domestic interest rates towards the long-run." In other words, floating exchange rate regimes are shown to have a higher degree of monetary independence than fixed regimes.

***De jure* vs. *De facto* Classification** An empirical challenge faced by many researchers in this field is classifying exchange rate regimes. When classifying exchange rate regimes one may use the volatility of exchange rates, also known as *de facto* classification, to determine whether a country is pegging or non-pegging. Another possibility is to simply use a country's self reported status provided by the IMF, known as *de jure* classification.

A phenomenon known as the 'fear of floating' describes a subset of countries that claim to be under a floating exchange rate regime when they are in reality intervening in the foreign exchange market. Calvo and Reinhart (2002) investigate the behavior of exchange rates and other economic indicators to assess whether the countries are accurately representing their policy stance. The data in their study spans thirty-nine countries on a monthly basis, from January 1970 to November 1990. Over the years, many emerging market economies have been hit with currency and banking crises, causing an overwhelming burden on these nation's economies. Many blame fixed exchange rate regimes as the cause. According to Calvo and Reinhart (2002), believers of this view have advised emerging market economies to switch to a floating exchange rate regime instead. The findings from Calvo and Reinhart (2002) suggest that some countries that claim to have a floating exchange rate regime actually do not. Although classified as 'floating', these countries are limiting the flexibility in their exchange rates, therefore not utilizing the monetary independence achievable with floating exchange rates.

Frankel, Schmukler and Serven (2004), conduct their study using both the *de facto* and *de jure* classification. Frankel et al. adopt the exchange rate classification procedure of Levy, Yeyati and Sturzenegger (LYS) (2000). The LYS classification system is determined "based on actual data on exchange rate and reserve variation." By using this *de facto* classification, they hope to avoid misclassifying the countries that are susceptible to 'fear of floating,' as discussed by Calvo and Reinhart (2002). These countries "would cause [the] empirical procedure to understate the monetary independence allowed by floating regimes – or, equivalently, overstate the degree to which local interest rates adjust to foreign rates under floating arrangements (p. 716)". On the other hand, some countries may declare themselves as pegged and actually continue to adjust their exchange rates. This could allow the government to set interest rates freely from world rates. This type of misclassification error could under estimate the "degree of monetary transmission under pegged regimes (p.716)". The de facto classification method aims to eliminate the possible bias introduced by the *de jure* classification.

To further compare the classification methods, Shambaugh (2004) finds that the de facto classification system produces similar results to the de jure classification provided by the IMF, with only 12 percent of the observations incorrectly classified. Shambaugh finds that the majority of the misclassifications are countries that appear to float, however are actually countries that are classified as pegs in the *de facto* classification. Shambaugh concludes that the declared status provided by the IMF "is not as bad an indicator as some have claimed (p. 320)." In my own work I am using the *de facto* classification method developed by Shambaugh (2004). A detailed discussion of this method is given in Section 5.1.

3 Theoretical Approach

3.1 Explaining the Trilemma Through the IS-LM-FX Model

The IS-LM-FX model consists of three markets, the goods market, money market, and the foreign exchange market. I start by discussing the derivation of the IS curve. The foundation of the IS curve can be expressed through the goods market. The goods market consists of the total supply of final goods, which corresponds to the Gross Domestic Product (GDP). Demand consists of consumption (C), investment (I), government expenditures (G) and the trade balance (TB).

$$Supply = GDP = Y, \tag{1}$$

$$Demand = D = C + I + G + TB. \tag{2}$$

The goods market equilibrium condition is satisfied when *Supply* = *Demand*. To fully derive the IS curve, we must first describe the Foreign Exchange (FX) market. The FX market is characterized by the uncovered interest rate parity, where the left side of (3) is the return on domestic bonds, called 'domestic return' and the right side is the return from investing in foreign bonds, termed 'expected foreign return'. In (3), i represents the domestic country's interest rate, i^*represents the foreign country's interest rate, $E[e]$is the expected log exchange rate, and e is the domestic country's current log exchange rate.

$$i = i^* + (E[e] - e). \tag{3}$$

Equilibrium in the FX market is reached when the domestic return is equal to the expected foreign return. The IS curve depicts each combination of output, Y, and the interest rate, i, for which the goods and the FX market are in equilibrium. This results in a downward sloping IS curve: as the interest rate falls, investment spending increases, resulting in higher levels of output. The final component of this model is the money market, which is described by the LM curve. Let M be the nominal money supply and P the aggregate price level. The velocity of money is referred to as the frequency at which the average unit of currency is in circulation. In this case we let , $L(i)$ be the inverse of the velocity of money. Then, the LM curve is given by

$$\frac{M}{P} = L(i)Y.$$

In the money market, $\frac{M}{P}$, represents the real money supply while $L(i)Y$, is the real money demand. The equilibrium condition in the money market is satisfied when real money supply is equal to real money demand. The LM curve is upward sloping because of the positive relation between income and the demand for money.

Floating Exchange Rate Regimes To understand the basic mechanism of the IS-LM-FX model through floating exchange rates we begin with an example. We assume that there is a temporary money supply shock to the domestic country that causes the money supply to increase. An increase in the money supply causes a decrease in the domestic interest rate resulting in the LM curve to shift down, maintaining overall output, Y. A decrease in the domestic interest rate makes foreign deposits more attractive causing the domestic country's exchange rate to depreciate (increase in value). This causes a simultaneous decrease in domestic and foreign returns. Finally, looking at the demand equation from (2), the lower domestic interest rate increases investments and the depreciation of the domestic exchange rate also increases the trade balance. This overall increase causes the domestic output to increase. Under a floating exchange rate regime the domestic country is able to make monetary policy decisions, thus causing the LM curve to shift. Based on the foreign exchange market and the uncovered interest rate parity, seen in (3), the domestic exchange rate depreciates in response to the decrease in the domestic interest rate. Therefore, the domestic interest rate and foreign interest rate move in a less than one-to-one relationship.

Fixed Exchange Rate Regimes Now we look at the IS-LM-FX dynamics under a fixed exchange rate regime and open capital markets. We consider the same scenario as described above, a temporary monetary shock in the domestic country. In a fixed exchange rate regime the domestic interest rate must equal the foreign interest rate. From (3), we hold the domestic exchange rate, e fixed, so that the expected exchange rate depreciation is equal to zero. It follows that

$$i = i^*. \tag{4}$$

Under the floating regime conditions, an increase in the money supply would shift the LM curve down and to the right causing the domestic interest rate to decrease. This would result in the depreciation of the domestic exchange rate. However, in the fixed exchange rate scenario the exchange rate cannot increase. An increase in the value of the exchange rate would break the peg to the foreign country. In a fixed exchange rate regime, policy makers are therefore unable to alter monetary policy in the domestic country. They must leave the current money supply fixed and the economy can not deviate from the initial equilibrium position. Thus, monetary policy autonomy is not possible under a fixed exchange rate regime with capital mobility. A potential benefit of monetary policy autonomy, as discussed above, is the ability of the central bank to increase output through expansive monetary policy and influence the economy in the short run. Contrary to floating exchange rate regimes, countries that employ a fixed exchange rate regime combined with open capital markets are forced to let their interest rates move in a one-to-one relationship with foreign rates and thus forego the ability to stabilize domestic business cycles

3.2 New Keynesian Model - Improved Theoretical Framework

This section considers a more modern theoretical framework to address the limitations of the simple IS-LM-FX model, described in Section 3.1. The IS-LM-FX model is useful for basic insights on the dynamics and policy tradeoffs for different countries. However, there are some limitations to the model. The original model has no uncertainty, it is a static model and monetary policy is represented in terms of quantity targets rather than interest rate targets (Obstfeld & Rogoff, 1995). The IS-LM-FX model represents a very short run view of the economy because the prices are assumed to be fixed. In the long run, prices adjust and the New Keynesian model takes that into account. The modern New Keynesian model is built around rational agents, monopolistic competition, price rigidity and monetary policy that follows a Taylor rule to set the interest rate. For the purposes of this project I will use a log-linearized version that leads to equations similar to the IS-LM-FX model Despite the similarity with the simple IS-LM setting, the New Keyensian model is able to address the limitations of the classical IS-LM-FX framework and delivers a full characterization of the equilibrium dynamics of the economy.

The theoretical framework considered is a two country model used to examine the transmission of economic shocks through a vector auto regressive (VAR) model. This model is based on specifications in Clarida, Gali and Gertler (2002)or Woodford (2010) and will be solved using the techniques of Dees, Peseran & Smith (2010). In this scenario each country has an equation representing the forward looking Philips curve,

$$\pi_t = \beta_b \pi_{t-1} + \beta_f E_t(\pi_{t+1}) + \beta y_t + \varepsilon_{st}, \tag{5}$$

where π_t, is the rate of inflation of a country at time t, $E_t(\pi_{t+1})$ is the expected rate of inflation at time $t+1$ where E_t represents the expectation operator conditional on information available at time t, and y_t is output.

Next, the IS curve is represented by,

$$y_t = \alpha_b y_{t-1} + \alpha_f E_t(y_{t+1}) + \alpha_r[r_t + E_t(\pi_{t+1})] + \alpha_e re_t + \alpha_{y*} y_t^* + \varepsilon_{dt} \tag{6}$$

where, once again y_t and $E_t(\pi_{t+1})$ are defined the same as above, $E_t(y_{t+1})$ is the expected output at time $t+1$, r_t and re_t are the interest rate and the real effective exchange rate at time t respectively, and finally $y^*$is foreign output, or in this case output from the United States.

The Taylor Rule is expressed as follows,

$$r_t = \gamma_\pi \pi_t + \gamma_y y_t + \varepsilon_{mt} \tag{7}$$

where ε_{mt} is an unobserved monetary policy shock that is not anticipated by the agents in the model. Finally the Real Effective Exchange Rate is represented by

$$re_t = \varepsilon_{et}. \tag{8}$$

The variables in the final two equations are defined in the same way as mentioned in Equation 5 and Equation 6. The equation for the IS curve represents the relationship between interest rates and output, which is defined as the "real aggregate demand for each of the two countries' products (Woodford, 2010 p.21)." The Taylor rule equation expresses monetary policy as an interest rate target. In this case the central bank sets interest rates based on inflation and output. The Real Effective Exchange Rate equation represents the Purchasing Power Parity relationship. We assume that both domestic and foreign goods are consumed in each country. It is further assumed that "each good is sold in a world market, and that the law of one price holds (Woodford, 2010 p.18)." Thus we have,

$$P_t = \tilde{E}_t P_t^* \tag{9}$$

where P_t and P_t^* represents the domestic and foreign country price level respectively and $\tilde{E}_t$ is the nominal exchange rate. Equation (9) reflects the law of one price and the fact that both countries have identical consumption baskets and complete international financial integration. Finally, the Phillips curve equation, (5), illustrates the decision on how much to produce and adjust prices.

3.2.1 Two Country Model

To begin developing the two country model we must start by re-arranging all the equations from the previous section to have only contemporaneous variables on the right-hand side. Let the domestic country be 'x' and the foreign country (the United States) be depicted by '*'. The domestic country (x) will have the following equations,

$$\pi_{xt} = \beta_{xb}\pi_{x,t-1} + \beta_{xf}E_t(\pi_{x,t+1}) + \beta_{xy}y_{xt} + \varepsilon_{x,st} \tag{10}$$

$$y_{it} = \alpha_{xb}y_{x,t-1} + \alpha_{xr}[r_{xt} - E_t(\pi_{x,t+1})] + \alpha_{xe}re_{xt} + \alpha_{xf}E_t(y_{x,t+1}) + \alpha_{xy^*}y_{xt}^* + \varepsilon_{x,dt} \tag{11}$$

$$r_{xt} = \gamma_{x\pi}\pi_{xt} + \gamma_{xy}y_{xt} + \varepsilon_{x,mt} \tag{12}$$

$$re_{xt} = \varepsilon_{x,et}. \tag{13}$$

The foreign country, in this case the United States (*), will have the following equations,

$$\pi^*_{0t} = \beta_{0b}\pi_{0,t-1} + \beta_{0f}E_t(\pi^*_{0,t+1}) + \beta y^*_{0t} + \varepsilon^*_{0,st} \tag{14}$$

$$y^*_{0t} = \alpha_{0b}y_{0,t-1} + \alpha_{0r}[r^*_{0t} - E_t(\pi^*_{0,t+1})] + \alpha_{0e}re^*_{0t} + \alpha_{0f}E_t(y^*_{0,t+1}) + \alpha_{0y}y_{0t} + \varepsilon_{0,dt} \tag{15}$$

$$r^*_{0t} = \gamma_{0\pi}\pi^*_{0t} + \gamma_{0y}y^*_{0t} + \varepsilon^*_{0,mt}. \tag{16}$$

The combined seven equations written for the domestic country and the foreign country, can be represented in matrix form. We begin by defining the 7×1 vector

$$\chi_t = [\pi_{xt}, \pi^*_t, y_{it}, y^*_{0t}, r_{xt}, r^*_{0t}, re_{xt}]^{'},$$

where χ_t represents each equation and the associated endogenous variables. Let the matrix A_0 be a representation of the full model without the lagged terms, A_1be a representation of the lags and A_2 account for the expectation coefficients. Once the system of equations are represented in matrix form and after combining the domestic country and the foreign country, it can be written as a simultaneous system of equation represented by,

$$A_0\chi_t = A_1\chi_{t-1} + A_2E_t[\chi_{t+1}] + \varepsilon_t \tag{17}$$

where ε_t is a 7×1 vector containing all the error terms

$$\varepsilon_t = [\varepsilon_{x,st}, \varepsilon_{0,st}, \varepsilon_{x,dt}, \varepsilon_{0,dt}, \varepsilon_{x,mt}, \varepsilon_{0,mt}, \varepsilon_{x,et}]^{'}.$$

Then we compute the following, $A = A_0^{-1}A_1$, $B = A_0^{-1}A_2$ and $\eta_t = A_0^{-1}\varepsilon_t$. These definitions lead to a semi-reduced form of the model where

$$\chi_t = A\chi_{t-1} + BE_t[\chi_{t+1}] + \eta_t.$$

This rational expectations model will then be solved using the procedure in Dees et.al. (2010) such that it has a reduced form VAR representation $\chi_t = \phi\chi_{t-1} + v_t$ and where $v_t = (I - B\phi)^{-1} A_0^{-1}\varepsilon_t$ is the reduced form error. The solution to this model, discussed in more detail in Appendix A, shows how exogenous shocks spread through the system and cause endogenous relationships between all variables in the system of equations. The implications of endogeneity for my empirical work are discussed in Section 3.2.2.

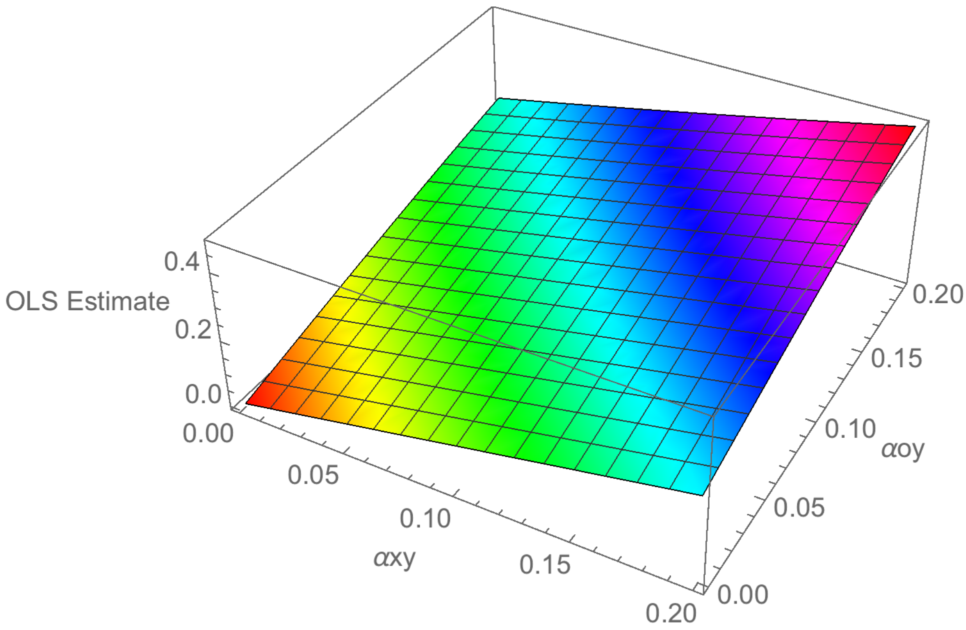
3.2.2 Problems of Endogeneity

After solving the model, described in 3.2, we can see that the term $v_t = (I - B\phi)^{-1}(A_0^{-1}\varepsilon_t)$, represents the effect of a shock on the state variables χ_t. The component $A_0^{-1}\varepsilon_t$ is the immediate contemporaneous effect and $(I - B\phi)^{-1}$ accounts for feedback through expectation terms. It can be shown analytically that all of the variables in the system of equations depend on all shocks. In other words, any shock that impacts any of the various equations in the two country model, shown in Section 3.2.1, will result in an endogenous response of all the other variables in the system.

For clarity, we look at two specific examples of endogeneity and analyze the mechanisms through which they enter the model. To begin, we examine a global shock, such as an oil price shock. A sudden alteration in global oil prices will increase cost, thus affecting supply in both the domestic and foreign country. This feeds into the system through the Philips curve in both countries, shown in (10) and (14). Also, due to interest rate targeting, the domestic and foreign countries will react to this shock resulting in a simultaneous move of both interest rates. This shows that both interest rates depend on the same common shock and therefore the base country interest rate is endogenous. Another source of endogeneity could originate from the domestic country and through spill over effects, impact the foreign country as well. More specifically, a credit market shock in the domestic country directly affects the error term in the Taylor Rule equation, (12), impacting interest rates. The new interest rate enters the IS curve (11), causing domestic output to change. This feeds into the foreign country's IS curve, (15), altering their output as well. Through this chain of events, we can clearly see that shocks can originate at the global level or the country level, and have an impact on both the domestic and the foreign country. This analysis shows that the theoretical model displays a richer set of interactions than discussed by Obstfeld. In turn, there are multiple channels for endogenous responses and the signs of biases are less clear.

The following graph shows a simple numerical illustration to compute model implied population OLS coefficients , solved in Appendix A. Model parameters used to generate the graph are based on a parametrization used in Svensson (2000). The x and y axis represent various values for trade weights in the domestic and foreign country IS equations, described as αxy and αoy respectively. The z axis shows the model implied population OLS parameter as a function of different combination of values for αxy and αoy . Consistent with the empirical evidence, model implied OLS coefficients are close to zero even though structural equations implied by the Taylor rule imply a structural parameter of one for the base country interest rate.

The values for αxy and αoy vary between 0 and .2, making the values comparable to the others in the model.



4 Empirical Specifications

4.1 Explanation of the Instrumental Variable

This section discusses the selection of instruments and justifies their use within the model framework laid out in Section 3.2.1. First we begin by discussing the Ordinary Least Squares (OLS) model. The original OLS specification used by Shambaugh (2004) and various other authors mentioned in Section 2, follow the form,

$$\triangle R_{it} = \alpha + \beta \times \triangle R_{bit} + \mu_{it} \tag{18}$$

where $\triangle R_{it}$ is the change in the domestic country interest rate and $\triangle R_{bit}$ is the change in the base country interest rate. In this case the base country is the United States. As discussed in the previous sections, the model implies that the change in the U.S interest rate is in fact endogenous, because it is a function of all the error terms in the model. Therefore the OLS parameter estimate is invalid. To correct for the problems of endogeneity we use the instrumental variable technique.

An instrumental variable will be used to instrument for the change in the U.S interest rate. For the first stage regression, I regress the change in the base country interest rate, in this case the United States, onto the difference between Federal Funds Futures Rate (FFF) and the Target Rate measured at the end of the month prior to U.S monetary policy changes. Exact measurement of the differential on the last trading day of the prior month is achieved by using daily data for Federal Funds Futures maturing at the end of the following calendar month. As discussed by Angrist, Jorda and Kuersteiner (2017), Federal Funds Futures are ideal measurements of market sentiment about the future course of monetary policy because their pay-off depends on the level of the target rate over the contracted period. We let the federal funds futures rate be denoted as f_{t-1}, and the target rate as r_{t-1}. The instrument $z_{t-1}$is defined as the spread between f_{t-1} and r_{t-1}, and is given as

$$f_{t-1} - r_{t-1} = z_t. \tag{19}$$

Angrist, Jorda & Kuersteiner (2017) mention that f_{t-1} "reflects both uncertainty about whether and when a target rate change will occur in t and more general uncertainty about the economy [...] (p.18)." Therefore, the difference between the futures rate and target rate is considered the "best risk adjusted predictor of a target rate change during the coming month," and can be used as an instrument for the change in U.S interest rates.

Consistent estimation of the parameter β in Equation 18 is not possible with OLS if the base country's interest rate is endogenous. Endogeneity is acknowledged as possible problem in the empirical literature, for example by Obstfeld (2015). Possible sources of endogeneity include common shocks or coordinated responses by central banks. A more basic point is that Equation 18 suffers from omitted variable bias for countries with floating exchange rates because the expected change in the exchange rate is absorbed into the error term. To overcome these problems this paper considers an instrumental variables strategy where the previous month differential between the Federal Funds Future and the target rate is used to predict US monetary policy. Thus, it is necessary to discuss why (19) is exogenous and can be used in the IV regression. At a heuristic level the instrument is valid because it is observed in the month prior to interest changes and as long as the error term in Equation 18 is not predictable. More formally, it can be seen from the Taylor rule equations that current period interest rates only depend on lagged values of the state vector through the inflation and output variables. When a country pegs their interest rate, these terms are absent. This then ensures the validity of the instrument and also provides the necessary exclusion restriction. These points are discussed in more detail in the next section.

4.2 IV vs. OLS - Theoretical Approach

Solving the theoretical model provides insights into possible biases for the coefficient estimates from both the IV and OLS approach. To better understand the similarities and differences between the two techniques, we look at the estimation of Pegging and Non-Pegging countries separately.

Pegging Countries The Uncovered Interest Parity (UIP) relation implies that if a domestic country is classified as pegging their interest rate must be equal to the base (foreign) country's interest rate and the expected depreciation of the exchange rate must be equal to zero. The interest rate rule of the foreign country then can be written as

$$r_{xt} = r^*_{0t} + \varepsilon_{x,mt}.$$

To formulate an empirical version of this equation we compute the change in time $t+1$ by taking the difference between time $t+1$ and t. This implies that

$$\triangle r_{x(t+1)} = \triangle r^*_{0(t+1)} + \triangle \varepsilon_{x,m(t+1)} \tag{20}$$

where r_{xt} is the domestic country interest rate, r^*_{0t} represents the base country interest rate and $\varepsilon_{x,mt}$ is the error term. From Equation 20 we can see that there is no omitted variable bias for pegging countries. However, based on the solution of the theoretical model, r^*_{0t} still depends on all shocks in the error term and is therefore correlated with the error term. This analysis shows that the OLS regression is expected to be biased, which is contrary to what the literature assumes. In this scenario, to control for the bias found in the OLS specification I implement the instrumental variable approach. The proposed instrument, described in Section 4.1, is dated at time $t-1$, this produces the correct parameter estimate since the instrument is not correlated with the error term, $\varepsilon_{x,mt}$ and at least for the case of pegging countries, there are no lagged endogenous variables, that could potentially violate the exclusion restriction included in the model. Therefore the instrumental variable technique is able to eliminate the bias found in the OLS specification.

Non-Pegging Countries The empirical equation used for Non-Pegging countries is computed by taking the difference between the domestic and the foreign country Taylor Rule at time $t+1$ and t, given by

$$\triangle r_{x(t+1)} = \triangle r^*_{0(t+1)} + \underbrace{\triangle\big(\gamma_{0\pi}\pi^*_{0(t+1)} - \gamma_{x\pi}\pi_{x(t+1)} + \gamma_{0y}y^*_{o(t+1)} - \gamma_{xy}y_{x(t+1)}\big)}_{omitted} + \triangle\big(\underbrace{\varepsilon_{0,m(t+1)} - \varepsilon_{x,m(t+1)}}_{error}\big)$$

Performing an OLS regression on the above equation omits the indicated term, leading to omitted variable bias. Another source of bias comes from the fact that r^*_{0t} is a function of all elements of the combined error terms, thus correlated with ε_{t+1}. Once again, this proves that the OLS estimate is biased for the Non-Pegging country specification. Unlike in the case for Pegging countries, the instrumental variable technique is not a valid estimator for the coefficient on $\triangle r^*_{0(t+1)}$in the empirical specification for the Non-Pegging countries. In this scenario the omitted variables are serially correlated and due to this serial dependence correlated with the instrument. The solution to the theoretical model, shown in Appendix A, demonstrates that the omitted variables depend on the lagged variables through the term $\phi\chi_{t-1}$. Thus, using instrumental variables for the Non-Pegging countries will not be able to recover correct parameter estimates. Although not analyzed in this paper, a possible way to amend this issue would be to include the omitted variables in the estimated equation and then find variables to use as instruments for each of the additional terms in the regression. Such a specification would lend itself for an alternative empirical test of monetary independence: If the foreign central bank were able to set interest rates independently from the base country rate, these added variables should be significant determinants of the foreign interest rate. Such an analysis is left for future work.

5 Data and Methodology

I collect data from the IMF International Financial Statistics (IFS) database, which provides information regarding exchange rates against the U.S dollar and various interest rate measures for 103 countries. My data spans from 1990 to 2016 and is on a monthly basis. I then classify countries as pegging or non-pegging based on the monthly exchange rate volatility. I merge the individual data files for all 103 countries to construct a single panel data sets for all countries. There are three panel data sets I produce, one each at annual, monthly and quarterly frequencies. The monthly files are used for the main part of the empirical analysis in this paper. However, for better comparison with results in the literature I also provide some analysis using the annual data. Once the country panels are constructed, the next step consists in merging the monthly interest rate and exchange rate data of all countries with U.S monetary policy data. The latter includes the federal funds futures rate and the target rate. The data for US monetary policy are at a daily frequency. This allows to measure the differential between market expectations captured by the federal funds future and the actual target rate on the last day prior to the month of the change in the US base rate, thus improving the predictive power of the instrument. The following subsections provide a detailed explanation of the intermediate steps, beginning with the fundamentals of classifying the exchange rate regimes, a discussion of the Shambaugh (2004) replication procedure and finally a discussion of the the instrumental variables procedure.

5.1 Exchange Rate Regime Classification

To classify the countries as pegging and non-pegging, I use Shambaugh (2004)'s *de facto* classification methodology. Using monthly data the first step is to find the midpoint among the exchange rates for each year. I calculate the range of the exchange rates for a given year and divide the value by two, which can be seen in (21). To find the midpoint value, I compute the sum of $e_{min} + e_R$, shown in (22). Next, I find the percent change between the exchange rate at month t, (e_t) and midpoint value, (e_{mid}), as shown in (23).

$$e_R = \frac{e_{max} - e_{min}}{2} \tag{21}$$

$$e_{mid} = e_{min} + e_R \tag{22}$$

$$e_{pct\triangle} = \frac{e_t - e_{mid}}{e_{mid}} \times 100. \tag{23}$$

If $e_{pct\triangle}$stays within a $\pm 2\%$ band, then that month is classified as pegging and if the value is outside the $\pm 2\%$, the month is classified as non-pegging.

5.2 Shambaugh (2004) Replication

Since the data used by Shambaugh (2004) are not publicly available, a replication exercise of his results is used to establish to what extent the data I am using are comparable to his. This allows me to isolate differences in the results due to differences in the data from other specification issues such as moving from annual to monthly data. Assuming free capital mobility, Shambaugh utilizes the uncovered interest rate parity to demonstrate that the difference in the base country and the domestic country interest rate is equal to the expected depreciation in exchange rates. The uncovered interest parity relation, in differenced form, is

$$\triangle R_{it} = \triangle R_{bit} + \triangle E_t[e_{t+1} - e_t] + \triangle \rho_t \tag{24}$$

where $\triangle R_{it}$ represents the change between t and $t-1$ in the domestic interest rate at a given time t, followed by $\triangle R_{bit}$which is the change in the base country's interest rate at time t. The $\triangle E_t[e_{t+1} - e_t]$ term represents the change in the expected depreciation of the exchange rate at time t. Finally, $\triangle \rho_t$, is the change in the risk premium.

Similar to Shambaugh, I assume that $\triangle \rho_t = 0$, in other words, the risk premium is constant at least over the observation frequency. Empirical work on risk premia, such as Piazzesi and Swanson (2008), shows that "risk premia do not change over small intervals (pg. 689)." Piazzesi and Swanson also cite Evans and Marshall (1998), who believe that risk premia only display minuscule responses to policy shocks, thus can be differenced out. In addition, Bluedorn and Bowdler (2010) discuss that if a change in the risk premium "moves in the same direction as $\triangle E_t[e_{t+1} - e_t]$ following a foreign interest rate change, our baseline predictions are maintained (pg. 685)," . This leads them to assume $\triangle \rho_t = 0$.

Continuing the discussion on the uncovered interest rate parity, if the base country engages in a credible peg, then the expected exchange rate and the current exchange rate must be the same. In other words, volatility in the currency is eliminated so that the expected value of the exchange rate is equal to the current exchange rate. It follows that $\triangle E_t[e_{t+1} - e_t] = 0$ and that

$$\triangle R_{it} = \triangle R_{bit}. \tag{25}$$

Another assumption Shambaugh makes is that the base interest rate is exogenous. This allows to estimate the equation by Ordinary Least Squares (OLS) leading to the following regression specification:

$$\triangle R_{it} = \alpha + \beta \times \triangle R_{bit} + \mu_{it}. \tag{26}$$

Under a credible peg β will be equal to 1, implying that the domestic country interest rate must move one-to-one with the base country.

If a country is under a floating exchange rate regime, or a peg that is not credible, the interest rate in the domestic country will move in a less than one-to-one proportion with the base country. The error term in (26) then contains the term $\triangle E_t[e_{t+1} - e_t]$. Under a floating exchange rate regime $\triangle E_t[e_{t+1} - e_t]$ is likely correlated with $\triangle R_{bit}$ because changes in the base interest rate, such as monetary policy changes, likely trigger movements in the exchange rates. Bluedorn et al. (2010) argue that this is a cause of upward bias in the OLS estimate of β. Changes in the base country's interest rates will cause the spot exchange rate in the domestic country to move until equilibrium is reached. The mechanics of this system is discussed in Section 3.

5.2.1 Replication Methodology

As previously mentioned, data that Shambaugh uses for his analysis is not publicly available. For this project I use publicly available data provided by the IMF IFS database. The same data source is also used by Frankel et al.. The data that I gathered is divided into three separate files, as discussed in Section 5. I begin with the annual file that contains data averaged throughout the months in a given year. Shambaugh's data set consists of the time period from 1960 to 2000 for 103 countries, while the data set I am using spans from 1990 to 2017. Shambaugh computes two sets of results, one for the entire sample and one for the years 1990 to 2000. To properly match my results with his, I also restrict my sample from 1990 to 2000 in some of my regressions. Shambaugh uses a combination of the Money Market Rate and the Treasury Bill rate, to define a variable for the domestic interest rate (R_{it}). For the countries that do not have data on the Treasury Bill rate, the Money Market rate is used and vice versa. This methodology results in the least number of missing values for R_{it}, the domestic interest rate. Once the type of interest rate is determined for each country, the year over year changes in the annual average Treasury Bill rate and the Money Market rate are calculated and included in the replication data set. Shambaugh provides a specific definition to drop countries facing multiple years of hyperinflation. Similar to Shambaugh, I also remove Argentina from 1981 to 1992, Brazil from 1983 to 1995 and Israel from 1983 to 1986. Initially, my Annual data set only considers the United

States as the base country for all the countries in the data set. However, Shambaugh determines the base countries based on historical importance. To enhance comparability I also implement this procedure. I then run a standard OLS regression for the entire data set from 1990 to 2000. Then I divide the sample based on exchange rate regime and run the same regressions separately for countries that are classified as pegging and no-pegging. Tables summarizing the replication results are provided in the appendix in Section 8.

Following the same procedure, I use the monthly data set to extract a yearly subset. To complete this task, I go through the entire Monthly file and select the first month of each year. For example, if the first month in the year 1990 is January, I select that row and place it in a separate annual chart. This allows me to compute the year over year change based on monthly data. OLS regression results with this data set are also provided in Section 8. I use these results to compare the results from the annual average data set to determine which specification of annual changes is more similar to Shambaugh's results.

5.2.2 Instrumental Variable Methodology

As mentioned in Section 4.1, the instrumental variable is the difference between the federal funds futures rate and the target rate, shown in (19). The first stage regression equation is as follows,

$$\triangle \hat{R}_t = \hat{\theta}_0 + \hat{\theta}_1 \times Z_{t-1} \tag{27}$$

where $\hat{\theta}_0$ and $\hat{\theta}_1$are obtained from a regression of the change in the base interest rate on the instrument. The second stage regression uses the estimated value from the first stage regression. This value is placed in the OLS regression equation. The second stage regression equation is as follows,

$$\triangle R_{it} = \alpha + \beta \times \triangle \hat{R}_t + \epsilon. \tag{28}$$

The β coefficient estimate will be analyzed and compared to the yearly results provided by Shambaugh.

6 Results

6.1 Shambaugh Replication Discussion

The following Tables 1, 2 and 3 provide the results from the replication procedure. Tables 1 and 2 give basic descriptive statistics of the data that was collected from the IMF IFS database. The first table, Table 1, provides the information from the Annual Average data set. This data set consists of observations that were calculated by taking the average of all the months in a given year. The second table, Table 2, consists of descriptive statistics from the data set that consists of differenced observations based on monthly observations of the first month of each year. While comparing the two tables, we can see that the results are very similar. The mean interest rate differential and standard deviations are slightly higher in Table 2 than in Table 1. The positive interest rate differential in both tables signifies that the base country has lower interest rates than the local country. Both Table 1 and Table 2 show that the pegged country interest rate differentials have a smaller mean than the differential for non-pegged countries. This means that the pegged countries move closer with the base country and are more stable than their non-pegged counterparts. A similar table was constructed in Shambaugh (2004). The results calculated by Shambaugh are very similar to the descriptive statistics provided above. This shows that the interest rate data used by Shambaugh and my data are comparable in terms of their descriptive statistics.

The next table, Table 3, presents the OLS regression results from Shambaugh's paper as well as the replication results. The first column of Table 3, shows the results calculated by Shambaugh in his paper. The first panel consists of the results from the full data set (observations from 1990-2000), followed, by the panels for 'Pegged' and 'Non-Pegged' countries. We first examine the two columns under 'Shambaugh Base,' the first column here uses the Annual Average data and the second column uses the data with twelve month differences calculated from data for the first month of each year. Both of these columns show results that are qualitatively similar to Shambaugh's results. However my sample size falls a bit short in terms of the number of observations, while Shambaugh has 886 observations, I have 852. The β coefficient, using the Annual Average data is, .193 and the coefficient estimate found by Shambaugh is .44. The 'Pegged Countries' panel also show qualitatively similar results as Shambaugh, however the β coefficient from the Annual Averages is .62 and Shambaugh's coefficient estimate is .56. The 'Non-Pegged Countries' panel shows a negative β coefficient estimate for the Annual Averages. The differences in the results could be due to smaller sample size I am using for the replication. Also, the data set I am using may be slightly different than Shambaugh's data set. However, the basic implications of the trilemma still holds for the results I found. The pegging countries have a higher coefficient estimate, which means that their interest rates are more closely related to the changes in the base country's interest rates. On the other hand, the non-pegging countries', seem not to be correlated with the base country at all. The second half of Table 3, includes the results from using the U.S as the base country for all the countries. From these results we can see that the coefficient estimates are slightly smaller than the estimates from using multiple base countries, however, the basic implications of the trilemma are also confirmed in this sample; the β coefficients for pegging countries are larger than the coefficients for non-pegging countries.

The final row of Table 3, provides the $p-value$ to determine the significance of the difference between the pegging and non-pegging countries. At a .05 significance level, the Annual Average column under 'Shambaugh Base' and the 12 month Difference column under 'U.S. Base', have the only significant differences. Therefore, the overall results seem to be qualitatively similar to Shambaugh's results with a few discrepancies. These differences may be due to the fewer number of observations in my data set and also because I may have some missing interest rate data.

I also compare my results with Obstfeld (2015). In this paper, Obstfeld compares the effects of short-term and long-term interest rates. My results are similar to Obstfeld (2015) for both the case where the US is the only base country as well as using multiple base countries. Obstfeld's results can be found in Obstfeld (2015), Tables 3 and 4. In Table 3, I get negative coefficient estimates for the non-pegged countries, which is similar to the results provided by Obstfeld. After comparing my results to both Shambaugh (2004) and Obstfeld (2015), I conclude that the data I have gathered can be used to produce similar results as published work.

6.2 Ordinary Least Squares Replication Extension

To further explore the implications of the trilemma, I include an extension of the OLS replication analysis. In addition to the basic replication data set, I analyze results for the developed countries, the developed countries excluding the countries with the Euro currency and developing countries. A list of countries used is provided in Appendix B. These various country subsets are examined for 1990-2000, the same time period used by Shambaugh (2004). For further analysis I include regression results for three different time periods, that span the entire data set: 1991-2000, 1991-2008, and 2000-2008.

The developed countries are a subset of nations that are more industrialized, have a higher per capita income and more advanced technological infrastructure. Many of the countries that have adopted the Euro currency are considered developed. To account for the fact that these countries have the same exchange rate against the U.S dollar, I exclude them from the data set to compare the result. The developing countries are classified as having a less developed industrial base and a low human development index. The list of developing countries used in this paper is based on the World Bank Database classification.

The annual averages classification, twelve month differences and monthly data, show a higher β coefficient for the pegging countries than the non-pegging countries. Table 5 shows the results for the developed, developed excluding the Euro area, and developing countries. As the literature assumes, we expect to find the coefficient for the pegging countries to be much closer to one than the non-pegging countries. We can see this relationship in Columns (7)- (9) in Table 5. Column (7) shows the results for annual averages and we see that the coefficient under the pegging classification for developing countries is .711 and the non-pegging coefficient is -.685. Similarly, Column (8), which shows the results for the twelve month differences, and column (9), which shows the results at the monthly frequency, show an analogous relationship. Thus, we can say that the developing countries follow an identical pattern as postulated by the literature. However, the developed countries depict an entirely different scenario. Columns (1)-(3), shows the results for all of the developed countries and Columns (4) - (6) shows the results for all the developed countries that are not part of the Euro area. The annual averages and the twelve month differences specifications for both specifications have a higher β coefficient estimate for non-pegging countries than pegging. This may be due to the fact that the annual averages and twelve month differences involve additional data transformation and because of the dynamics of the model we end up with different predictions. However, Columns (3) and (6), which depict the results calculated at a monthly frequency, show the pegging countries with a higher coefficient than the non-pegging countries. The differences in coefficient estimates could be due to the sample size, as the monthly frequency has more data points than the annual frequency. Data transformations implicit in yearly observations could cause additional discrepancies in the results between monthly and annual data.

The other subsets analyzed, shown in Table 4, look at different time periods. The Shambaugh replication exercise uses data from 1990-2000. However, in my data, the interest rate changes in the year 1990 are calculated as zero because there is no data from the previous year. To avoid the change equaling zero, I look at the data from 1991 to 2000. The coefficient estimates, at the annual and monthly level are comparable, showing no significant differences after excluding 1990 from the sample. The purpose of including the other two time specifications is to see whether the exclusion of the years after the 2000 does affect the coefficient estimates. The results from these periods are consistent with the findings from the 1990-2000 sample.

Over all, the OLS replication for extended specifications presents similar coefficient estimates produced by Shambaugh (2004). The coefficient estimates for pegging countries are not as high as the theory predicts. From the theoretical framework, completed in Section 4.2, we know that the OLS specification is biased for both pegging and non-pegging countries. The pegging countries do not experience omitted variable bias. I still anticipate to find endogeneity in the change in the base country interest rate based on my theoretical analysis. On the other hand, Non-pegging countries encounter both omitted variable bias and problems of endogeneity. Therefore, the OLS coefficient estimates, discussed above, cannot be expected to be accurate measurements of the underlying structural parameters. To adjust for the problems of endogeneity and omitted variable bias I use instrumental variables to compare the results, which will be discussed in the next section.

6.3 Instrumental Variable Regression Results

The results presented in Shambaugh (2004), Obstfeld (2015) and Frankel, Schmukler and Serven (2004) show a coefficient estimate of less than one for pegging countries. For example, Shambaugh produces a β coefficient of .56 for pegging countries and makes the claim that pegging countries move in a one-to-one relation with their base country. Parameter estimates well below one could be due to endogeneity in the change in the base country interest rates. At least for pegging countries, an instrumental variables estimator should result in parameter estimates much closer to one. It is worth noting at this point that the OLS estimates for monthly observations are generally even further biased away from one than is the case for annual data. In my sample, the United States is used as the base country and the difference in the change of the federal funds futures rate and the target rate is used to instrument the change in the U.S. interest rate, as shown in Section 4.

To validate my instrumental variable strategy, I check the first stage IV results for the three different data sets: annual averages, twelve month differences and monthly data. The annual averages and the twelve month differences describe two different definitions to calculate annual changes in the data while the monthly frequency utilizes monthly changes. Table 6, displays the first stage regression results. From Table 6 we can see that the first stage of the IV regression is weak for the annual data, with an unusually high standard error. The annual averages data set has a standard error of 5.444 and the twelve month differences data set has a standard error of 6.705. Large standard errors are mostly due to the very small sample sizes at the annual frequency. On the other hand, when calculating the first stage regression results for the monthly differences the instrument proves to be strong, with a standard error of .185 and a statistically significant coefficient estimate of .753.

The instrumental variable technique is used to calculate coefficient estimates for the same subsets of data as considered in the Shambaugh (2004) replication, discussed in Section 5.2. Since the instrument proved to be weak for annual data the results are difficult to interpret and lack statistical significance and therefore are not included in the Tables. However, the results from the monthly data on these subsets show coefficient estimates closer to one for pegging countries. The data is provided in extensive detail in Tables (7) and (8). Table 7 includes the IV results for all of the countries in the sample, developed, developed excluding the Euro area, and developing countries. Column (1), shows the results for the entire data set. Here we see coefficient for the pegging countries to be .884, which is very close to one and the coefficient for non-pegging countries to be -.995. Shambaugh (2004) obtained an OLS estimate for pegging countries to be .56, while I produce a coefficient estimate of .62 for the annual averages definition and .33 for the twelve month differences definition. Comparing the OLS results to the IV results, we can clearly see that the IV result is able to recover a parameter estimate much closer to one, which is predicted by the literature and the theoretical analysis. As mentioned in Section 3.2.2, the instrumental variable will be able to account for the bias found in pegging countries. This can be seen in the results, as the coefficient estimates for pegging countries are significantly closer to one. An interesting finding, are the coefficient estimates for the developed countries and developed countries excluding the Euro currency. In this scenario, we find the coefficient estimate for the Pegging countries to be larger than one. Similarly, the developing countries also have a Pegging coefficient estimate of .751, which is significantly higher than the OLS estimate found in the monthly sample, shown in Column (9) in Table 5.

The different time periods were also analyzed for the IV regression in Table 8. Under these time specifications, the pegging countries had a higher coefficient estimate than the Non-Pegging countries. When comparing these findings to the OLS results at the monthly frequency, we see that the IV estimate is larger than the OLS estimate, bringing the parameter estimate closer to one. The sample from 1991-2000, at the monthly level, had an OLS coefficient (Column (3), Table 4) for pegging countries to be .372, while the IV estimate, for that same specification, seemed to drastically increase to .932. The other estimates only slightly increased in value from their respective OLS results.

The results for non-pegging countries for these various specifications show a pattern that is compatible with my theoretical analysis. As discussed in Section 4.2, the non-pegging countries experience both omitted variable bias as well as endogeneity. The omitted variables invalidate the instrument due to their serial correlation, resulting in correlation of the error term with the instrument. Thus, the instrument is invalid in the case of non-pegging countries. The IV results lead to coefficient estimates for the non-pegging countries that are consistently negative and significantly different from the Pegging countries estimates. This is in line with what the model predicts. A more detailed analysis of the structural equations implied by the model requires empirical specifications that account for determinants of monetary policy in foreign and base countries. This is left for future work.

7 Conclusions

The replication of Shambaugh's results allows me to determine whether the data set I am using is comparable to the data set used by Shambaugh. Although there are a few differences, the results are qualitatively similar. I include a few different variations in the analysis, developed countries, developed countries excluding the Euro currency, developing countries and three different time periods. In particular, I checked the OLS regression results excluding the year 1990. However, this alteration does not provide any significant differences from having 1990 in the sample. Switching from annual to monthly data, I find similar coefficient estimates in the OLS regression. The replication exercise and the addition of different subsets of countries allows me to explore the sensitivity of the results to different specifications. This is particularly relevant because monthly data are more suitable for the instrumental variables strategy I use. Overall, the data I use lead to results that are qualitatively similar to the results from Shambaugh (2004).

After completing the first stage of the instrumental variable regression, it is apparent that the instrument is a weak predictor for annual data but a strong predictor for monthly data. When analyzing the monthly data, the instrumental variable regression results show coefficient estimates of pegging countries much closer to one in the over all dataset as well as for the developed and developing countries. This shows that instrumenting for the change in the U.S interest rate is capturing the bias in the estimates, as found in the theoretical analysis completed in Section 4.2. The theoretical analysis also exposed the fact that the instrument is not valid for Non-Pegging countries due omitted variables that are serially correlated.

Overall, this project was able to use a VAR model to identify the sources of endogeneity, not accounted for in the literature. The theoretical model also provides justification of the proposed instrument both in terms of exogeneity and exclusion restrictions. Since the instrument is lagged at time $t-1$, it can be excluded from the structural equation and therefore is also exogenous in the model. The empirical results are largely consistent with predictions of the theoretical analysis. In particular, I find IV coefficient estimates for pegging countries that are much closer to one than corresponding OLS estimates.

Although not completed in this paper, it is possible to collect data for the omitted variables in the Non-Pegging countries regression equation. Adding these additional covariates and instrumenting for them allows to test additional theoretical predictions of the model: do interest rates of non-pegging countries respond to domestic inflation and output measures even after controlling for base country interest rates. As presented in 3.2.2, I calculated OLS coefficient estimates based on the theoretical model by varying the value of the trade parameters in the domestic and foreign country IS equations. In addition to this analysis, it would be highly beneficial to also compute the direction of the bias in the IV regression for the non-pegging countries. To do this we would need to price assets in the spirit of a consumption based asset pricing model to determine the future rate implied by the model. In this model, the futures price is a linear combination of the state vector of the model. Once this linear combination is determined, the population properties of IV estimates can be computed in the same way as for the OLS estimator.

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8 Tables

Table 1: DESCRIPTIVE STATISTICS FOR ANNUAL AVERAGES

	Full Sample	Pegged Countries	Non-Pegged Countries
$(R_{it} - R_{bit})_{\ mean}$	.06	.017	.09
$(R_{it} - R_{bit})_{\ stddev}$	.11	.04	.13
$R_{it\ \ stddev}$	.11	.04	.13
$R_{bit\ \ stddev}$	.02	.03	.02

The data used in Table 1 is calculated by taking the twelve month average of each year.

Table 2: DESCRIPTIVE STATISTICS FOR 12 MONTH DIFFERENCES

	Full Sample	Pegged Countries	Non-Pegged Countries
$(R_{it} - R_{bit})_{\ mean}$	.07	.02	.09
$(R_{it} - R_{bit})_{\ stddev}$	.12	.05	.15
$R_{it\ \ stddev}$	.12	.05	.15
$R_{bit\ \ stddev}$	.02	.03	.02

The data used in Table 2 is calculated by take the difference between the first month of each year.

Table 3: OLS RESULTS

		Shambaugh Base		US Base for all Countries	
	Shambaugh	Averages	Differences	Averages	Differences
	(1)	(2)	(3)	(4)	(5)
		Full Sample 1990's			
# obs	886	852	780	852	783
β	.44**	.193**	.33**	-.097	.033
Std. Error	.15	.16	.14	.18	.21
Robust Std. Error	–	.18	.18	.22	.25
R^2	.013	.0017	.007	.0003	.000
		Pegged Countries 1990's			
# obs	327	328	295	322	297
β	.56**	.62**	.35**	.27**	.239
Std. Error	.06	.08	.06	.11	.135
Robust Std. Error	–	.11	.24	.135	.15
R^2	.13	.18	.08	.017	.015
		Non-Pegged Countries 1990's			
# obs	525	524	485	530	486
β	.35	-.208	.303	-.328	-.09
Std. Error	.25	.27	.268	.29	.329
Robust Std. Error	–	.33	.285	.34	.396
R^2	.006	.001	.002	.0024	.002
$p - value$ for differences		.01	.85	.114	.045

The columns (2) and (4) are analyzed using data that was averaged throughout an entire year. On the other hand, columns (3) and (5) uses data that is observed by taking the difference between the first month of each year. The values with '**' denote the statistical significance at a .05 significance level. Columns (2) and (3) use the base countries established by Shambaugh(2004). Columns (4) and (5) use only the U.S as the base countries for the entire data set. I compute the Robust standard error in this table to show that there is no significant difference between the robust standard error and the standard error. Since there is no significant difference between the two, I only provide the standard error in the remainder of the tables.

Table 4: Other OLS Time Period Specifications

	1991-2000			1991-2008			2000-2008		
	Avg. (1)	Diff. (2)	Monthly (3)	Avg. (4)	Diff. (5)	Monthly (6)	Avg. (7)	Diff. (8)	Monthly (9)
Full Sample									
#N	766	750	9375	1445	1398	17728	761	729	9356
β	.186	.128	.148	.248	.00278	.184	.288	-.129	.182
Std. Error	(.170)	(.158)	(.169)	(.145)	(.228)	(.156)	(.212)	(.428)	(.235)
Pegged Countries									
#N	290	285	3559	614	600	6124	356	349	2859
β	.624***	.215***	.372*	.479***	.242***	.519***	.359***	.359***	.565*
Std. Error	(.0874)	(.0725)	(.185)	(.0776)	(.0702)	(.152)	(.115)	(.124)	(.232)
Non-Pegged Countries									
#N	476	465	3580	831	798	6499	405	380	3303
β	-.209	-.00617	-.150	.0647	-.270	-.0195	.239	-.539	.0137
Std. Error	(.290)	(.313)	(.374)	(.250)	(.442)	(.386)	(.370)	(.808)	(.605)
p-value	.015	.496	.320	.158	.264	.160	.780	.296	.320

The table above shows the OLS results for different time periods. The original analysis is done at an annual frequency from 1990-2000, however, to check how the coefficient estimates compare at different time periods, we add a few particular time specifications as shown above. The last row shows the p-value for the differences between the pegging and non-pegging countries.

Table 5: Other OLS Country Specifications

	Developed			Developed No Euro			Developing		
	Avg. (1)	Diff. (2)	Monthly (3)	Avg. (4)	Diff. (5)	Monthly (6)	Avg. (7)	Diff. (8)	Monthly (9)
				Full Sample					
$\#N$	415	376	4958	287	141	3421	434	404	5259
β	.492***	.733***	.109	.429***	.626***	.2213	.0163	.0708	.0718
Std. Error	(.0858)	(.114)	(.144)	(.108)	(.141)	(.189)	(.278)	(.230)	(.279)
				Pegged Countries					
$\#N$	181	162	1458	116	99	950	138	133	2345
β	.459***	.528***	.334	.317***	.319***	.732	.711***	.301***	.345
Std. Error	(.0857)	(.0678)	(.182)	(.0985)	(.0909)	(.234)	(.137)	(.109)	(.269)
				Non-Pegged Countries					
$\#N$	234	214	1787	171	154	945	296	271	2207
β	.506***	.846***	-.141	.520**	.786***	-.205	-.685	-.629	-.315
Std. Error	(.136)	(.184)	(.364)	(.172)	(.215)	(.6506)	(.465)	(.551)	(.552)
p-value	.299	.897	.080	.5	.989	.017	.219	.120	.185

This table shows the various country subgroups analyzed at the annual and monthly level from 1990-2008. Columns (1)-(3) show the results of the developed countries, while columns (4)-(6) depicts the developed countries that do not use the Euro currency. Columns (7)-(9) show the OLS coefficient estimates for the developing countries. The last row of the table shows the p-value for the differnces between the pegging and non-pegging countries.

Table 6: First Stage IV Regression Analysis

	Annual Avgs. (1)	Twelve Month Diff (2)	Monthly (3)
$\#N$	11	11	132
β	6.683	3.969	.753***
Std. Error	(5.444)	(6.705)	(.185)

This table shows the first stage IV regressions results. We can see that the IV is a weak predictor for both definitions of annual data. The coefficient estimate for the monthly data is statistically significant at the .01 significance level, thus a strong predictor.

Table 7: Instrumental Variable Results: Monthly

	All Countries (1)	Developed (2)	Developed No Euro (3)	Developing (4)
	Full Sample			
$\#N$	10217	4958	3421	5259
β	-.0307	-.1842	-.0707	.121
Std. Error	(.160)	(.428)	(.558)	(.836)
	Pegged Countries			
$\#N$	3803	1458	950	2345
β	.884	1.061	1.325	.751
Std. Error	(.179)	(.429)	(.581)	(.764)
	Non-Pegged Countries			
$\#N$	3394	1787	945	2207
β	-.995	-1.87	-2.141	-.254
Std.Error	(.347)	(1.295)	(2.245)	(1.718)
p-value	.091	.006	.025	.574

This table depicts the instrumental variable results for different subsets of countries. Monthly data is used from 1990-2000 to calculate these results. Column (1) shows the coefficient estimates for all the countries, followed by the different subsets of countries. The last row represents the p-value for the differences between pegging and non-pegging countries. Columns (2) and (3) have a significant p-value at the .05 significance level. This shows that that the differences between the pegging and non-pegging countries in developed countries are significant.

Table 8: Instrumental Variable Results Monthly: Other Time Specification

	1991-2000 (1)	1991-2008 (2)	2000-2008 (3)
	Full Sample		
#N	9374	17728	9356
β	-.170	-.0741	.0348
Std. Error	(.426)	(.307)	(.417)
	Pegged Countries		
#N	3559	6124	2859
β	.932*	.429	.157
Std. Error	(.444)	(.296)	(.407)
	Non-Pegged Countries		
#N	3580	6499	3303
β	-1.335	-.511	-.0407
Std.Error	(.967)	(.777)	(1.082)
p-value	.019	.208	.877

This table shows the analysis of the IV regression for three different time periods at a monthly frequency. The last row of the table shows the p-value for the differences between pegging and non-pegging countries. From the table we can see that the time span from 1991-2000 shows a significant difference between pegging and non-pegging at the .05 significance level.

A Mathematical Solution of VAR Model

As mentioned in Section 3.2.1, this model focuses on two countries, a domestic and foreign country. After combining the equations from the domestic and the foreign country we can see that there are seven simultaneous equations to be solved. The equations are as follows,

$$\pi_{xt} = \beta_{xb}\pi_{x,t-1} + \beta_{xf}\tilde{E}_t(\pi_{x,t+1}) + \beta_{xy}y_{xt} + \varepsilon_{x,st}$$

$$y_{it} = \alpha_{xb}y_{x,t-1} + \alpha_{xr}[r_{xt} - \tilde{E}(\pi_{x,t+1})] + \alpha_{xe}re_{xt} + \alpha_{xy^*}y^*_{xt} + \varepsilon_{x,dt}$$

$$r_{xt} = \gamma_{x\pi}\pi_{xt} + \gamma_{xy}y_{xt} + \varepsilon_{x,mt}$$

$$re_{xt} = \varepsilon_{x,et}$$

$$\pi^*_{0t} = \beta_{0b}\pi_{0,t-1} + \beta_{0f}\tilde{E}_t(\pi^*_{0,t+1}) + \beta y^*_{0t} + \varepsilon^*_{0,st}$$

$$y^*_{0t} = \alpha_{0b}y_{0,t-1} + \alpha_{0r}[r^*_{0t} - \tilde{E}(\pi^*_{0,t+1})] + \alpha_{0e}re^*_{0t} + \alpha_{0y}y_{0t} + \varepsilon_{0,dt}$$

$$r^*_{0t} = \gamma\pi^*_{0t} + \gamma_{0y}y^*_{0t} + \varepsilon^*_{0,mt}$$

The first four equations depict the domestic country and the last three are for the foreign country. Now we construct matrices to represent the system of equations. The matrices are as follows:

$$\chi_t = [\pi_{xt}, \pi^*_t, y_{it}, y^*_{0t}, r_{xt}, r^*_{0t}, re_{xt}]',$$

$$\varepsilon_t = [\varepsilon_{x,st}, \varepsilon_{0,st}, \varepsilon_{\mathbf{x,dt}}, \varepsilon_{0,dt}, \varepsilon_{x,mt}, \varepsilon_{0,mt}, \varepsilon_{x,et}]'.$$

$$A_0 = \begin{vmatrix} 1 & 0 & -\beta_{xy} & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & -\beta_{0y} & 0 & 0 & 0 \\ 0 & 0 & 1 & -\alpha_{xy} & -\alpha_{xr} & 0 & -\alpha_{xe} \\ 0 & 0 & -\alpha_{0y} & 1 & 0 & -\alpha_{0r} & 0 \\ -\gamma_{x\pi} & 0 & -\gamma_{xy} & 0 & 1 & 0 & 0 \\ 0 & -\gamma_{0\pi} & 0 & -\gamma_{0y} & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{vmatrix}$$

$$A_1 = \begin{vmatrix} \beta_{xb} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & \beta_{0b} & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & \alpha_{xb} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \alpha_{ob} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{vmatrix}$$

$$A_2 = \begin{vmatrix} \beta_{xf} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & \beta_{0f} 0 & 0 & 0 & 0 & 0 & 0 \\ -\alpha_{xr} & 0 & \alpha_{xf} & 0 & 0 & 0 & 0 \\ 0 & -\alpha_{0r} & 0 & \alpha_{0f} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{vmatrix}$$

The vectors χ_t and ε_t represent the endogenous variables and exogenous shocks entering individual. The matrix A_0 describes the parameters of each of the contemporaneous terms in the equations, while matrix A_2 contains the parameters for each of the expectation terms and A_1 contains the parameters for the lagged terms.

Once the system of equations is represented in matrix form, as shown above, it can be written as a simultaneous system of structural equations

$$A_0\chi_t = A_1\chi_{t-1} + A_2 E_t\chi_{t+1} + \varepsilon_t.$$

To begin solving, we multiply both sides of the equation by A_0^{-1} to get,

$$\underbrace{A_0^{-1}A_0}_{I}\chi_t = \underbrace{A_0^{-1}A_1}_{A}\chi_{t-1} + \underbrace{A_0^{-1}A_2}_{B}E_t\chi_{t+1} + \underbrace{A_0^{-1}\varepsilon_t}_{\eta_t}$$

$$\chi_t = A\chi_{t-1} + BE_t\chi_{t+1} + C\eta_t.$$

This model is then solved using the procedure in Dees, et. al. (2010) such that it has a VAR representation

$$\chi_t = \phi\chi_{t-1} + \underbrace{\nu_t}_{C\eta_t}$$

The solution to the model satisfies that ,

$$\nu_t = \underbrace{(I - B\phi)^{-1}}_{C}\eta_t$$

and

$$B\phi^2 - \phi + A = 0.$$

This equation can be solved with an iterative numerical algorithm detailed in Dees, et. al. (2010). This leads to the reduced form

$$\chi_t = \phi\chi_{t-1} + \underbrace{(I - B\phi)^{-1}\eta_t}_{Endogeneity}.$$

To solve for the analytic solution for the OLS estimate we continue with the following procedure:

$$\Sigma = (I - B\phi)^{-1}A_0^{-1} \bullet \left(A_0^{-1}\right)' \left((I - B\phi)^{-1}\right)'$$

$$D = (I - \phi \otimes \phi)^{-1}$$

where I is the identity matrix. From here we solve for the variance-covariance matrix of the vector χ_t:

$$\Gamma = D \bullet vec[\Sigma]$$

After reshaping the Γmatrix back into a $7x7$matrix we can extract the covariance of r_{xt} and r^*_{0t} and the variance of r^*_{0t}. We then solve for the OLS population parameter- as follows,

$$\beta_{OLS} = \frac{Cov(r_{xt}, r^*_{0t})}{Var(r^*_{0t})}.$$

B List of Countries

Table 9: List of Developing Countries

Country Name	Exchange Rate Regime
Argentina	Pegging
Belize	Pegging
Benin	Non-Pegging
Bolivia	Pegging
Brazil	Non-Pegging
Burkina Faso	Non-Pegging
China,	Non-Pegging
Cote dIvoire	Non-Pegging
Dominica	Pegging
Dominican Republic	Non-Pegging
Egypt	Pegging
El Salvador	Non-Pegging
Ethiopia	Pegging
Fiji	Pegging
Ghana	Non-Pegging
Grenada	Pegging
Guatemala	Pegging
Guyana	Pegging
Haiti	Non-Pegging
India	Non-Pegging
Indonesia	Non-Pegging
Jamaica	Pegging
Kenya	Non-Pegging
Korea	Non-Pegging
Lao Peoples Democratic Republic	Non-Pegging
Lebanon	Pegging
Lesotho	Non-Pegging
Libya	Non-Pegging
Madagascar	Non-Pegging
Malawi	Non-Pegging

This table shows the developing countries, as classified by the World Bank, that are used in my analysis.

List of Developing Countries

Country Name	Exchange Rate Regime
Malaysia	Pegging
Maldives	Pegging
Mali	Non-Pegging
Mauritius	Non-Pegging
Mexico	Non-Pegging
Morocco	Non-Pegging
Mozambique	Non-Pegging
Namibia	Non-Pegging
Nepal	Pegging
Niger	Non-Pegging
Nigeria	Pegging
Pakistan	Pegging
Papua New Guinea	Non-Pegging
Paraguay	Non-Pegging
Philippines	Pegging
Romania	Non-Pegging
Senegal	Non-Pegging
Sierra Leone	Non-Pegging
Solomon Islands	Non-Pegging
South Africa	Non-Pegging
Sri Lanka	Non-Pegging
St. Lucia	Non-Pegging
St. Vincent and the Grenadines	Non-Pegging
Swaziland	Non-Pegging
Tanzania	Non-Pegging
Thailand	Pegging
Togo	Non-Pegging
Tunisia	Non-Pegging
Turkey	Non-Pegging
Uganda	Non-Pegging
Vanuatu	Non-Pegging
Venezuela	Non-Pegging
Zambia	Non-Pegging
Zimbabwe	Non-Pegging

This table shows the developing countries, as classified by the World Bank, that are used in my analysis.

Table 10: List of Developed Countries

Country Name	Exchange Rate Regime	Euro Currency
Antigua and Barbuda	Non-Pegging	
Antilles	Non-Pegging	
Australia	Non-Pegging	
Austria	Non-Pegging	Euro
Bahamas, The	Non-Pegging	
Bahrain	Non-Pegging	
Barbados	Pegging	
Belgium	Non-Pegging	Euro
Canada	Pegging	
Denmark	Non-Pegging	
Finland	Non-Pegging	Euro
France	Non-Pegging	Euro
Germany	Non-Pegging	Euro
Greece	Non-Pegging	Euro
Hungary	Non-Pegging	
Iceland	Non-Pegging	
Ireland	Non-Pegging	Euro
Israel	Non-Pegging	
Italy	Non-Pegging	Euro
Japan	Non-Pegging	
Luxembourg	Non-Pegging	Euro
Malta	Non-Pegging	Euro
Netherlands	Non-Pegging	Euro
New Zealand	Non-Pegging	
Norway	Non-Pegging	
Poland	Non-Pegging	
Portugal	Non-Pegging	Euro
Seychelles	Non-Pegging	
Singapore	Pegging	
Spain	Non-Pegging	Euro
St. Kitts and Nevis	Non-Pegging	
Sweden	Non-Pegging	
Switzerland	Non-Pegging	
Trinidad and Tobago	Non-Pegging	
United Kingdom	Non-Pegging	
Uruguay	Non-Pegging	

This table shows the countries in the sample classified as developed and identifies those that are part of the Euro currency.