Abstract

Relative purchasing power parity (PPP) is the idea that bilateral nominal exchange rates between two countries change in proportion to their price level differential. This paper tests the theory using annual, quarterly, and monthly data for 37 different OECD nations. Specifically, bilateral nominal exchange rate data and relative consumer price indices (CPI) are used in both Augmented Dicky-Fuller (ADF) unit root tests and Johansen tests for cointegration. The results of these testing methods provide evidence in support of relative PPP in 30 of the 37 countries. Additionally, 12 of the 17 Eurozone countries also displayed evidence for relative PPP when Euro nominal exchange rates were appended to their pre-Eurozone domestic nominal exchange rates.

Introduction

In the current global environment, domestic currencies unlikely to backed by any tangible commodity. For example, the United States dollar is a fiat currency backed by the United States government as appropriate tender for all debts public and private. With the prevalence of the US dollar as an international currency, one might expect it to have the same value as a unit of exchange anywhere across the globe. That is, one might expect that similar goods in different countries would have the same price when expressed in a singular currency. For example, consider the fast-food giant McDonalds. In a perfect world, a Big Mac sandwich, as served by the many McDonalds establishments located across world, would have equal costs when converted to the same currency. However, as demonstrated by the decidedly tasty and informative Big Mac Index, this is not the case (The Economist Newspaper).

Bilateral nominal exchange rates represent the straight conversion rate from one currency to another. For example, a nominal exchange rate of 1.25 Canadian dollars for every 1 US dollar would indicate that one could exchange 100 Canadian dollars for 80 United States dollars. Thus, one could reasonably assume that a good or service that costs $80 in the US could be purchased for $100 in Canada given their shared nominal exchange rate. This relatively simple idea is known as purchasing power parity (PPP) in that purchasing power should remain equal regardless of the currency the actual purchasing is being done in. However, as shown by the Big Mac Index, as well as many other similar indices, this is often not the case.

Instead of using bilateral nominal exchange rates as an indicator of purchasing power, many economists turn to the real exchange rate (RER). This value is calculated as

$$RER = e\frac{P}{P^*},$$

where e represents the bilateral nominal exchange rate in foreign currency per domestic dollars and P/P^* represents the domestic to foreign price ratio of the two countries being compared. Either the price of singular goods or price levels for a basket of goods can be used in calculating the RER. A RER that is approximately 1 represents a domestic currency with an equivalent purchasing power as the foreign currency. Any other value else represents an imbalance in purchasing power for the two currencies. Yet, what value should be expected?

That question is exactly what the Theory of Purchasing Power Parity attempts to answer. In its strongest form, PPP suggests that if allowed to fluctuate freely, bilateral nominal exchange rates will change such that the RER is always equal to 1. This implies that one would have the same purchasing power regardless of the currency they are using to make transactions. Thus, although a Big Mac may cost different amounts in different countries, one would have the same ability to buy them in either currency once converted using the nominal exchange rate. A less demanding form of PPP is relative PPP. This form of PPP does not assume that RER is equal to 1. Instead, it just assumes that the bilateral nominal exchange rate changes in proportion to change in domestic prices compared to foreign prices. This implies that while RER may not equal 1, it remains at a consistent value. Thus, returning to our Big Mac example, the nominal exchange rate should grow at a rate equal to the rate of growth in the difference between domestic and foreign Bic Mac prices, or essentially the Big Mac inflation differential.

The idea of relative PPP will be the main focus of the paper. Although testing the effects of international Big Mac price differentials on bilateral nominal exchange rates would make for an interesting topic, this research instead focuses on macroeconomic indicators. Specifically, the paper aims to test the theory of relative PPP using real effective exchange rates (REER) which track the overall movements of national level price indicators and their associated nominal

exchange rates. In order to look for evidence in support of relative PPP, my research focuses on 37 developed countries within the Organization for Economic Cooperation and Development (OECD) with the United States as a domestic base. A review of the surrounding PPP literature is conducted in section 1. Section 2 discusses the specific data and methodology that I used for my paper while section 3 presents and discusses my results. Overall, we find evidence to support relative PPP theory in 30 of the 37 countries as well as 12 Eurozone extensions. I finally conclude the paper by discussing the various implications of my results as well as the limitations of the study as a whole. Although the methods I use for actually testing the theory of relative PPP are not novel, a thorough review of them, as well as the surrounding literature, would prove beneficial regardless.

1. Literature Review

This literature review will attempt to provide a treatise on the overall economic theory surrounding PPP in its relative and strong forms. However, given that the paper's focus is on relative PPP, I will more closely examine that theory as opposed to that of other forms PPP. I intend to begin by rigidly defining the hypotheses associated with PPP as well as discussing their original formulations and history. I will endeavor to carefully explain the implications a validity of PPP would suggest while also discussing what an adherence to PPP would most resemble in the international market. Moving beyond classical theory, I will then discuss the empirical findings around PPP. Special attention will be given to the debate between PPP in the short-term versus the long-term. As a further step, I will also explore some of the factors which could lead some countries to display stronger signs of an adherence to PPP while others do not. Once I have established a solid basis for the conceptual theory surrounding PPP, the varying statistical methodologies in testing for its presence overtime will be explored. Although the testing

methods in this particular paper will be more carefully explored in the data and methodology section, a cursory overview of the main PPP testing methods will be performed. My review will conclude by highlighting country specific results which can serve as a point of comparison for the results I generate later in the paper.

Defined loosely, PPP is the general notion that the nominal bilateral exchange rate between two nations is determined by the ratio of their price levels. This could be for individual goods, as mentioned in the introduction, however a more worthwhile consideration of PPP involves national-level macroeconomic factors. Economists and policymakers alike are particularly concerned with overall fluctuations as opposed to case-specific incidences in order to measure factors such as international competitiveness or trade flows. However, PPP theory cannot be simplified to one single premise. Instead, PPP is really an amalgamation of multiple premises and assumptions, each with varying degrees of strictness and each having their own hypotheses (Officer, 1976). Regardless, all PPP theory stems from a rather intuitive, albeit idealistic, theory.

Underlying Theory

The "law of one price" (LOP) simply states that the price of a specific good will be the same in all locations when quoted in the same currency. The theory implies that when converted to a singular currency measure of value, the price of identical goods in two different countries should be exactly the same. Mathematically, the LOP can be expressed as

$$P_i^* = eP_i,$$

where P_i and P_i^* represent the domestic and foreign good prices respectively for some good i with e simply representing the bilateral nominal exchange rate (Rogoff, 1996). Although the theory serves as a basis for inquiry into all other things PPP, few acknowledge the LOP's

empirical strength for price levels representative of goods baskets which include both traded and non-traded goods. Although the LOP has seen some support in highly traded commodities, the presence of transportation costs, quotas, tariffs, taxes, and any number of other associated costs associated with cross-border trading make the LOP unfeasible for most goods (Engel & Rogers, 1994).

The logical next step up from the LOP would be to consider national-level price indicators as opposed to singular goods. Thus, I now transition into the theory of absolute PPP. The hypothesis is very similar to the LOP except it uses price indices instead of individual good prices. In general, it states that when converted to a singular currency, country specific price-level indicators for two countries should be equal. The theory operates under the assumption that these comparable price indices, and their related market baskets, are comprised of the exact same goods with the exact same weighting. Thus, empirical comparisons for countries who use different goods baskets compositions can sometimes be problematic. Regardless, similar to the LOP, absolute PPP can be expressed mathematically as

$$P^* = eP,$$

where instead or representing individual goods, P and P^* represent the domestic and foreign price levels. However, this definition of absolute PPP is equivalent to postulating that the real effective exchange rate between the two countries stays firmly equal to 1. This can be shown mathematically by arranging the above equation as

$$1 = \frac{eP}{P^*} = REER.$$

Thus, the theory asserts that bilateral nominal exchange rates will be perfectly responsive and change relative to the price level ratio between the two countries. Regardless of any monetary or real shocks to the international economy, instantaneous arbitrage forces will put

pressure on nominal exchange rates such that REER will always remain constant at 1. Yet, similar to the LOP, absolute PPP is somewhat unrealistic outside the confines of theory. Although the costs associated with the LOP and the differences they cause still prove to be a confounding issue within absolute PPP, the use of price indices brings their own set of complications. Price levels and their component good measurements are often not uniform in their weighting from country to country and thus making international comparisons is difficult to do (Dornbusch, 1985). Similarly, choosing which price level measurements to use can serve to drastically influence results.

Although the LOP and absolute PPP do not hold up in practical study and application, they still serve to form the initial steps in unraveling the PPP mystery. A natural progression, and the main focus of my research, is the study of relative (or weak) PPP. Instead of dealing with exact values for price levels or nominal exchange rates, relative PPP focuses on how each of the variables change in relation to the others. Relative PPP is considered to be less stringent in its assumptions and objectively weaker than the two previously discussed premises. However, this relaxation makes relative PPP a better candidate for practical study and prevalence in empirical analysis. It is because of this that I dedicate the majority of this paper, and its contained research, to relative PPP.

Relative PPP is the idea that bilateral nominal exchange rates change in proportion to the difference between country price levels. For example, consider the scenario where the domestic country inflation is equal to 2% and while the foreign country inflation is only 1%. In this case, relative PPP would dictate that foreign currency would appreciate by 2%-1%=1%. This is expressed mathematically as

$$\hat{e} = \hat{P} - \widehat{P^*},$$

where $\widehat{\ }$ indicates percent change (Dornbusch 1985). This definition of relative PPP can also be tied to the concept of the REER in that

$$\widehat{REER} = \hat{P} - \widehat{P^*} - \hat{e} = 0.$$

Thus, relative PPP hypothesizes that although REER may not equal 1 as is the case in absolute PPP, nominal exchange rates will change as a result of market forces such that REER remains stable over time.

Relative PPP has several advantages over the two previous displays of PPP. Since relative PPP is only concerned with change, testing its validity does not require a standardized basket of goods which both countries share in equal proportion. Furthermore, the theory helps to eliminate associated cost problems experienced by the other two premises. Assuming that no real shocks occur to affect the economy, relative PPP serves to capture only the changes in price level experienced between the two countries. This circumnavigates any trading costs which would have affected absolute PPP or the LOP and instead focuses on the bilateral nominal exchange rate being coerced by arbitrage forces to change with the price level differential over time. This is not to say that relative PPP does not have its weaknesses. Picking an appropriate base period is key as it needs to be a relatively "normal" period that allows for a decent comparison over time. One could consider an ideal normal period to be one with a minimal, or lack of, economic shocks (Officer, 1982).

Historical Context

Although ideas that resembled PPP were present dating back to the Salamanca school and the Mercantilist era, it was only in the early twentieth century where it was first explored rigorously in an academic setting. This is primarily due to the efforts of Swedish economist Gustav Cassel. Global disturbances caused by the first World War gave Cassel the opportunity to

study this theory more closely, and his work “The Present Situation of the Foreign Exchanges” introduced other economists of the time to his theories (Cassel, 1916). Notably, John Maynard Keynes even took interest in PPP stating that “Thus defined, ‘Purchasing Power Parity’ deserves attention, even though it is not always an accurate forecaster of the foreign exchanges” (Keynes, 1923, p.77-78). PPP continued to be studied throughout the twentieth century by both economists and policymakers alike, especially in the monetary upheaval following the second World War. As the century progressed, novel methods of controlling nominal exchange rate regimes meant the economists frequently revisited the theory (Dornbusch, 1985).

Practical Applications

As research on PPP and exchange rates progressed, it became apparent to lawmakers that the data calculated as a result of PPP study could be used in the management of foreign economic affairs. Specifically, PPP and its related study have been used in assessing the true value of currency. Relative PPP postulates a stable REER in the long run. Any short-run shocks which serve to change the REER can then be compared to the long-run equilibrium to see if currencies are either undervalued or overvalued as a result. With this knowledge, policymakers and government institutions are able to appreciate or depreciate their currency as they see fit (Officer, 1982).

Another practical policy application comes in the form of inflation management. Countries which experience high rates of inflation usually must use a floating nominal exchange rate as they cannot afford the damages to trade caused by a fixed nominal exchange rate. Even the act of simply maintaining a fixed rate is difficult under these conditions. However, adopting a floating nominal exchange rate can itself become a problem if the floating rate proves to be too volatile. As a result, some countries adopt a ‘crawling peg’ policy in their exchange rate regimes.

Although a floating exchange rate is still used, countries set a nominal exchange rate target ‘peg’ which they will not allow the floating rate to deviate far from. In essence, they are attempting to speed up the long-term PPP equilibrium process and control the transition into this state by using both market pressure and command pressure to match the hypothesized outcome of PPP. Conversely, some governments will also deliberately drive their REER away from PPP equilibrium in order to gain economic advantages in trade. Real depreciation of exchange rates can create export-led growth which serves to increase employment domestically, while appreciating the value of the currency can ‘tighten’ the monetary supply of a nation and serve to curb inflation (Dornbusch, 1985).

Long-Run vs Short-Run

An important component in the relative PPP model is time. Theoretically, although shocks would affect nominal exchange rates as well as the REER, relative PPP suggests that these perturbations will eventually settle to an equilibrium. The question of when, however, is another story. Some shocks subside relatively quickly, while others may take years to fully recover (Rogoff 1996). Thus, contention between short-term and long-term studies with regards to their efficacy has been a major point of focus for researchers.

For short-term scenarios, the general consensus is that relative PPP does not hold. Frenkel (1981) found that in short-time spans with significant shocks, deviations from PPP are more likely to dominate than any equilibrium values. Furthermore, Krugman (1990) argues that any support for short-term PPP would be unfounded. He argues that both real and nominal shocks produce disequilibrium that does not subside quickly enough to provide evidence for any equilibrium. Furthermore, Krugman attributes an inflexibility in short-term factors that leads to disequilibrium situations being slow to dissipate. Thus, as financial and monetary shocks

influence the nominal exchange rate, the real exchange rate is thought to deviate in the short-term.

Given the relative lack of evidence found for short-term relative PPP, most empirical studies instead involve testing PPP in the long-term. Specifically, these studies are concerned with detecting convergent trends toward PPP and rejecting the null hypothesis that RER follows a random walk (Rogoff, 1996). Edison (1987) uses data from 1890-1978 to test PPP in regards to the dollar/pound exchange rate. The study finds that there is evidence to suggest some long-term convergence and stability in the dollar/pound REER. Gailliot (1970) was able to find evidence for the validity of PPP in the long run for eight countries with data spanning 1900-1967. Therefore, the modern consensus is that long-term relative PPP is a viable hypothesis worthy of further study, while short-term PPP is not as much so. As such, most modern studies are focused on exploring relative PPP in long-run studies.

An important question when assessing PPP is time frame. Specifically, how long do deviations from PPP usually last and how long do they take to dampen back down to equilibrium. For this, economists have introduced the concept of a PPP deviation half-life. A half-life is defined as the time needed for a deviation in PPP to dampen to half of its original change. The expected half-life for PPP has been found to be on average anywhere between three to five years. Although this may not sound like a long time, a half-life this large means that a reversion to be less than just 10% deviated away from the PPP equilibrium will take at least nine to fifteen years (Rogoff, 1996). Therefore, any studies involving relative PPP are expected to incorporate multiple decades worth of observations in order to attain any noteworthy results.

Country-Specific Factors affecting Relative PPP Evidence

Although I have explored the time related reasons as to why evidence for relative PPP may or may not be found, I have not yet investigated the country-specific factors which may affect relative PPP results. When Gustav Cassel first popularized the theory, he also hypothesized factors which could serve to cause the deviation of different regime types away from a relative PPP equilibrium. For example, frequent trade restrictions may be lopsided relative to imports and exports. If a country has tighter restrictions on its imports as opposed to exports, they might see a their REER exceed the relative PPP predicted equilibrium. Inflation anticipation or any long-term capital movements can also serve to create disequilibrium. As previously mentioned, governments may even have proper incentive to manually affect REER as well (Officer, 1982). However, an important theory to note in regards to relative PPP conditions is the Balassa-Samuelson hypothesis.

The hypothesis states that differentials in labor productivity between tradable and non-tradable goods sectors would lead to changes in real costs and relative price levels. Balassa and Samuelson both argue that richer countries are more technologically advanced than poor countries, but that the technological advancements are not evenly spread between sectors. Specifically, productivity growth in the traded goods sector is thought to outpace growth in the nontraded goods sectors. This increased productivity would be met with higher compensation, and as a result lead to a higher relative price for non-traded goods. Given that relative PPP calculations use national level price level observations which consider both sectors, persistent differentials could lead to disequilibrium (Asea & Corden, 1994). Thus, countries which tend to experience larger productivity differentials may see less of an adherence to relative PPP. These results, however, can only be explored if relative PPP can be reliably tested for.

Testing for Relative PPP

When testing the validity of relative PPP, there are three general methods which are used. Given that at a minimum relative PPP requires REER to fluctuate around a given mean, several works seek to test if the REER is stationary over time. As mentioned before, this involves checking to see if there exists a unit root within the data, i.e. seeing if RER follows a random walk. A random walk is exactly as the name implies; when graphed over time, the variances in a random walk data series are random. Thus, if the time series contains a unit root, REER is known to be systematically unpredictable and unstable. In this case, relative PPP is not supported. Therefore, the rejection of a unit root would give evidence in support of relative PPP. Rogoff (1996) expresses support for this method of testing and it is common in recent PPP literature (See Bianco (2008) or Mike and Kizilkaya (2019)). The second method of testing for relative PPP involves cointegration techniques. Relative PPP assumes that the bilateral nominal exchange rate and relative price levels are cointegrated (i.e. they move together over time) such that a summation of both cannot deviate from equilibrium in the long term. Testing to see if these two variables are in fact cointegrated is equivalent to testing the validity of relative PPP. Non-cointegrated variables would not provide evidence in support of relative PPP while cointegrated data would. This method of testing is also supported by Rogoff (1996) and is also common in recent literature (See Bianco (2008) or Hanck (2009). The third method of testing involves nonlinear testing methods. These check to see if REER is increasingly mean reverting and thus tied to some form of equilibrium (Bianco, 2008). For the purposes of this paper, I will only be focusing on unit root and cointegration testing methods as these are within the paper's scope.

Unit root tests are one of the most fundamental and widespread testing methods used to validate/invalidate PPP in a time series. These test for the stationarity of a variable within a

highly persistent time series and seek to determine whether a variable takes on the characteristics of a random walk or not. Thus, the existence of a unit root implies that the trend is not time stationary and that no equilibrium point exists (Wooldridge, 2012). The mechanics of the test will be explored later on in the paper, but there exist multiple unit root tests that are commonly used. These include Dickey-Fuller tests (Dickey, Fuller, 1979), Phillips-Perron Tests (Phillips, Perron, 1988), and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) tests (Kwiatkowski, Phillips, Schmidt, Shin, 1992). For the purposes of this paper, only the Augmented Dicky-Fuller test will be used.

The other method of testing used in this paper are cointegration tests. Cointegration deals with different sets of time series observations which seem to be integrated of order one. As mentioned before, time series trends are considered to be cointegrated if they can be combined in some manner such that their summation is effectively zero. Visually, this resembles time series trends which move in concert with one another (Wooldridge, 2012). For the purposes of relative PPP, the two time series trends of interest are the log of bilateral nominal exchange rates and the log of relative price levels. I will discuss the specific mechanics of cointegration tests later in the paper as well, but there are multiple standard tests which economists usually use in testing for relative PPP. These include the Engel Granger two-stage method (Engel, Granger, 1987) and the Johansen method (Johansen, 1991) as well as others. This paper will employ the Johansen method.

Empirical Evidence

Although there is a general support for relative PPP, there still exists some debate in the literature. Mike and Kizilkaya (2019) were able to find evidence of stationary trends which would suggest relative PPP in seven emerging market economies: Brazil, Colombia, India,

Mexico, South Africa, Thailand, and Turkey. Hanck (2009) employs a multiple testing approach to find comparable results in support of long-run PPP. Specifically, Hanck finds evidence for Argentina, Belgium, Finland, France, Germany, Italy, Mexico, Norway, Sweden, and the UK. However, some studies do not uncover any evidence in support of relative PPP. In an extensive 106-year examination of Argentinean REERs, Bianco (2008) finds no evidence for relative PPP. Chang and Tzeng (2013) also found no strong evidence to suggest long-run PPP with their data arguing against any such validity of PPP. In fact, there is even some disagreement involving short-term PPP. Suffice to say that there still exists plenty of opportunity to study relative PPP.

The inconsistency present in the study of relative PPP makes results such as mine all the more interesting. The theory has a rich history of study, with influential economists ranging from Keynes to Friedman all contributing to the PPP discourse. Yet, there is still plenty of opportunity for modern economists to add to the literature. With more powerful tools and robust methods of testing, the PPP puzzle will hopefully come closer to being solved. This paper will hopefully serve as a useful addition to the study of PPP as a whole.

2. Data and Methodology

As previously stated in the literature review, testing relative PPP is essentially testing the movement of the REER over time. The REER is calculated using price baskets for two different countries and their nominal exchange rate. Thus, we have

$$REER = e\frac{P^*}{P},$$

where P^* is the foreign price level, P is the domestic price level, and e is the nominal exchange rate in domestic currency per unit of foreign currency. Absolute PPP hypothesizes that REER should always be equal to one. However, in practical applications, shocks and other

macroeconomic factors will cause deviations in the REER. Thus, I will instead test the concept of relative PPP. My tested hypothesis is that, although there may be short deviations in REER, the overall time trend will gravitate towards the equilibrium value. I apply this theory by looking at international level data in price levels and nominal exchange rates for 37 OECD countries. Of these 37 OECD countries, 17 are a part of the Eurozone and as such have switched to the use of the Euro as a domestic currency. For these countries, two time series will be analyzed: one which contains only bilateral nominal exchange rates pre-Euro and one which sees the Euro nominal exchange rates appended to the individual domestic rates pre-Euro.

Testing relative PPP, as shown above, only requires collecting the variables used to calculate REER. Thus, for the purposes of this paper, I collect country specific price levels and bilateral nominal exchange rates. For our measure of price levels, I use consumer price index (CPI) levels. Although some contend that PPP should only be tested using indices which are comprised of solely traded goods such as the wholesale price index (WPI), I follow the initial suggestion of Keynes and instead use the consumer price index (CPI). Using CPI also comes with the added benefit of widespread data availability and most contend that CPI represents the average consumer bundle and provides a more accurate representation of the price levels faced nationally (Officer, 1982). It provides a more encompassing view of national price levels as it incorporates both traded and nontraded sectors. In the literature I reviewed, most studies used CPI data, exclusively All country price levels are taken annually, quarterly, and monthly from the International Monetary Fund (IMF) International Financial Statistics database. Bilateral nominal exchange rates are also taken from the IMF International Financial Statistics database. They represent the domestic currency per U.S. dollar period average for annual, quarterly, and monthly observations. As a result, all countries are being tested relative to the United States.

Observing the RER over time and testing my hypothesis requires finding the changes to REER over time. For that reason and for our time periods t, I use a logarithmic approach such that

$$\ln(REER_t) = \ln\left(\frac{e_t P_t^*}{P_t}\right).$$

Using the properties of a natural log, I can transform the change in REER into a linear equation. This is important as the statistical tests I employ rely on an implied linear relationship between the variables. Thus, if I let τ_t represent the percentage change in REER, $\ln(e_t) = \sigma_t$, $\ln(P_t^*) = \pi_t^*$, and $\ln(P_t) = \pi_t$ for our observation periods t, I have

$$\tau_t = \sigma_t + \pi_t^* - \pi_t.$$

Before any statistical tests are employed, I intend to simply graph the REER as a time series trend. A visual perspective could help in interpreting the later statistical results. Countries whose REER may appear to be more stable over time might show greater evidence of relative PPP than those who do not. Still, all visual observations and conclusions would be purely subjective and thus more rigorous statistical methods are still needed.

Our first such statistical method of testing for relative PPP is the Augmented Dicky Fuller (ADF) unit root test. This test is intended to provide evidence for the presence of a nonstationary trend in the REER time series data. A random walk would imply that the REER does not follow any predictable patterns over time and its movement is therefore arbitrary. A REER time series trend that follows the hypothesis of relative PPP would not display signs of a random walk and would thus not indicate the presence of a unit root. Consider the simple autoregressive model for RER below with error term ε_t:

$$\tau_t = \rho\tau_{t-1} + \varepsilon_t.$$

In testing for a unit root, I am concerned with the value of ρ. If $|\rho| < 1$, I know that τ_t converges to a stationary time series as t approaches infinity. However, if $|\rho| = 1$ I know that τ_t does not converge to a stationary time series as t approaches infinity. Thus, I am testing to see if the autoregressive time series model has exactly one unit root, $|\rho| = 1$. The standard Dicky Fuller approach tests the simple autoregressive model above and has a null hypothesis of $|\rho| = 1$. Thus, in order to support the theory that the calculated REER is a stationary variable I must reject the null hypothesis that $|\rho| = 1$.

However, for the purposes of this paper, I will follow the method used by Bianco (2008) and use the ADF unit root test. The ADF test is more robust in analyzing the presence of stationary trends within RER over time. The model builds upon the simple autoregression model by incorporating time lags. In order to calculate the optimal lag length p to apply to the autoregression, I choose the lag time p for which the Akaike information criterion (AIC) is minimized. The AIC acts as an estimate for predictive error in the model, thus choosing a lag which minimizes this value ensures that error is minimized. With this optimal lag, I now have the following model:

$$\tau_t = \rho_1 \tau_{t-1} + \sum_{j=2}^{p} \rho_j (\tau_{t-j} - \tau_{t-j-1}) + \varepsilon_t.$$

Within this framework, I am now concerned with the variable ρ_1. Specifically, if $|\rho_1| = 1$ I know there exists a unit root and the trend is not stationary, and if $|\rho_1| < 1$ I know that the time series converges to a stationary trend. The null hypothesis for the ADF unit root test is that $|\rho_1| = 1$ and therefore there does exist a unit root and the trend is not stationary. Thus, in order to prove the validity of PPP I must reject the null hypothesis. Using the specific nominal

exchange rate and price level data collected from the IMF, I can test for PPP in each country using the ADF methodology previously explained.

The second method commonly used in testing for PPP involves checking to see if the nominal exchange rate and price levels are cointegrated. The nominal exchange rate and the price levels may be nonstationary trends. However, if these two nonstationary trends are found to be cointegrated, then there exists a combination of these nonstationary variables which creates a stationary trend. Thus, if I find that the nominal exchange rate and the price levels are cointegrated, then I can say that there does exist a stationary trend in the REER. A stationary trend in turn provides evidence in favor of relative PPP. Thus, in order to provide evidence in support of relative PPP, I must show that bilateral nominal exchange rates and relative price levels are cointegrated over our time periods for a specific country.

In order to test for cointegration, I again follow Bianco (2008) and perform the Johansen test for cointegration. To account for our price levels, let

$$\kappa_t = \ln\left(\frac{P}{P_*}\right).$$

Ultimately, I am testing to see whether the log of relative price levels (κ_t) and the log of the bilateral nominal exchange rate (σ_t) are cointegrated. The Johansen test comes in two forms, trace tests and maximum eigenvalue tests. Regardless of the approach, however, the Johansen results determine the order for which our variables are integrated. If there exists a linear combination of the time series which produces a stable time series, then I conclude that the variables are cointegrated, which expresses support for relative PPP validity. The trace test method determines how many linear combinations exist between the two time series trends. For our null hypothesis, I assume that there exist no linear combinations between the data, thus a rejection of the null indicates that the variables are cointegrated. Maximum eigenvalue tests, as

the name implies, determine the value of the largest eigenvalue. If that value is greater than or equal to one, I know that there exist one or more cointegrating vectors. However, for purposes of the paper, I am only testing two variables, κ_t and σ_t. In this case, the maximum number of cointegrating vectors is two and thus I am therefore testing to see if there exists exactly one cointegrating vector. If there were two, this would imply that both variables are stationary, which does not make sense in our assumptions. Thus, the null hypothesis for the Johansen maximum eigenvalue test is that there exists only one cointegrating vector. If I reject the null, then I am actually implying that the time series trends are not cointegrated and that PPP is not validated. Therefore, a non-rejection of the null hypothesis is desired for supporting PPP when employing the Johansen maximum eigen value test method.

I perform both the ADF and Johansen tests on each of the 37 countries and 17 associated extensions for annual, quarterly, and monthly observations. To constitute as evidence in favor of relative PPP, the ADF or Johansen tests must return any form of a relative PPP supportive result for at least one of the 3 period types. Strong evidence, however, would be the presence of strong indictive results across each of the three period types. I include all three types of observations in order to produce more evidence. Monthly data will include the most observations and therefore hopefully provide the most robust results. However, observing quarterly and annual data too is important as their results can serve as a comparator. Inconsistent results across the three period types could merit some pause in our acceptance of the evidence.

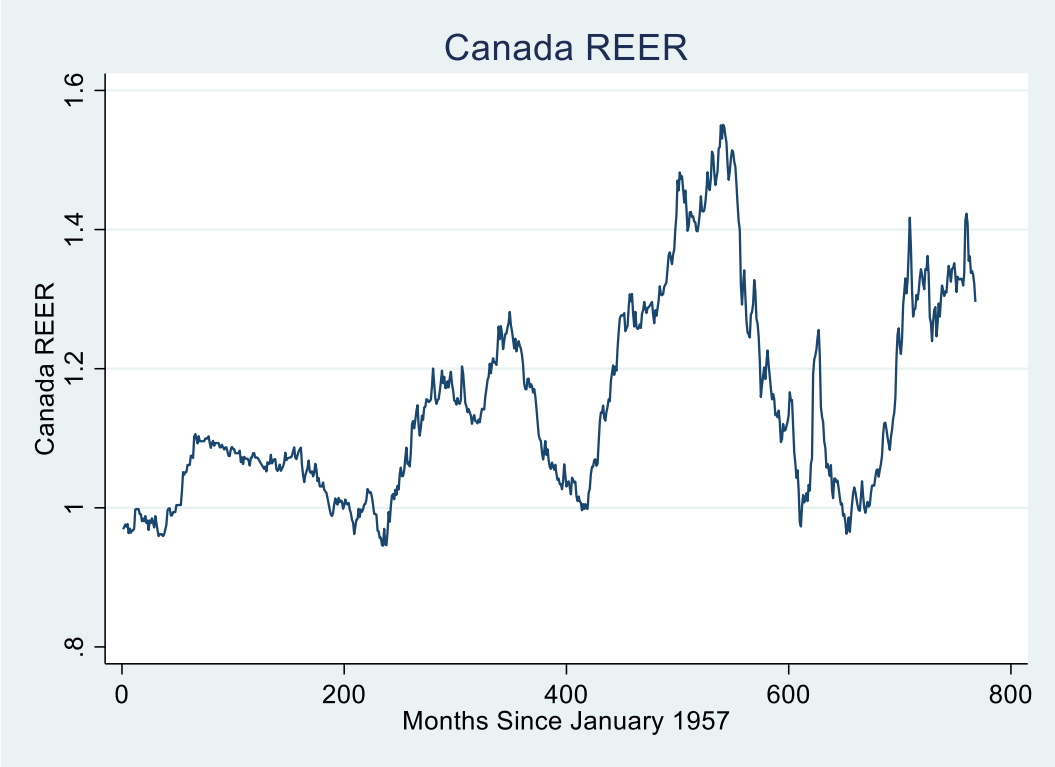
3. Results

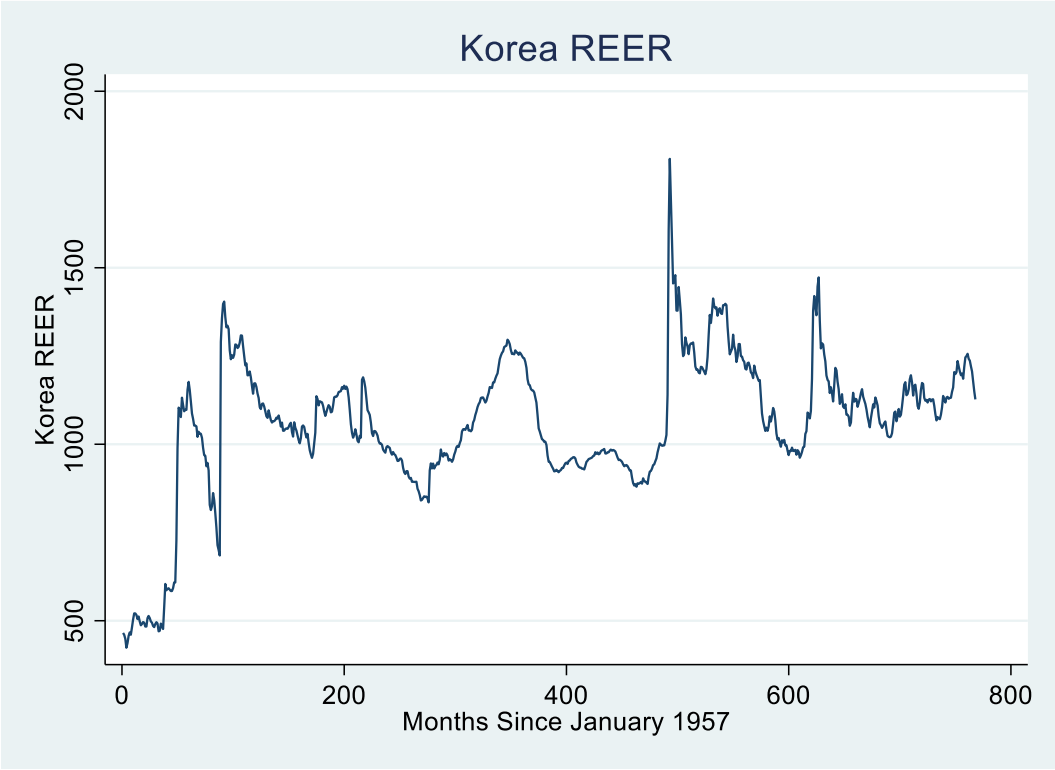
As previously stated, the results come in the form of critical values produced by performing the ADF and Johansen tests for each of the OECD countries. The null hypothesis of the ADF tests assume that there exists a stochastic trend within the data, thus a significant result

indicates that there exists some stationary trend and provides evidence in support of relative PPP. The null hypothesis for the Johansen tests conducted combines both the trace and eigenvalue methods. For my results, the tests assume that the variables are not cointegrated and thus a significant result would indicate that there is cointegration which serves as evidence in favor of relative PPP. Therefore, those results which are significant for both the ADF tests and Johansen tests provide strong evidence in favor of relative PPP. However, it would be wise to first identify the candidates for relative PPP graphically before running any tests.

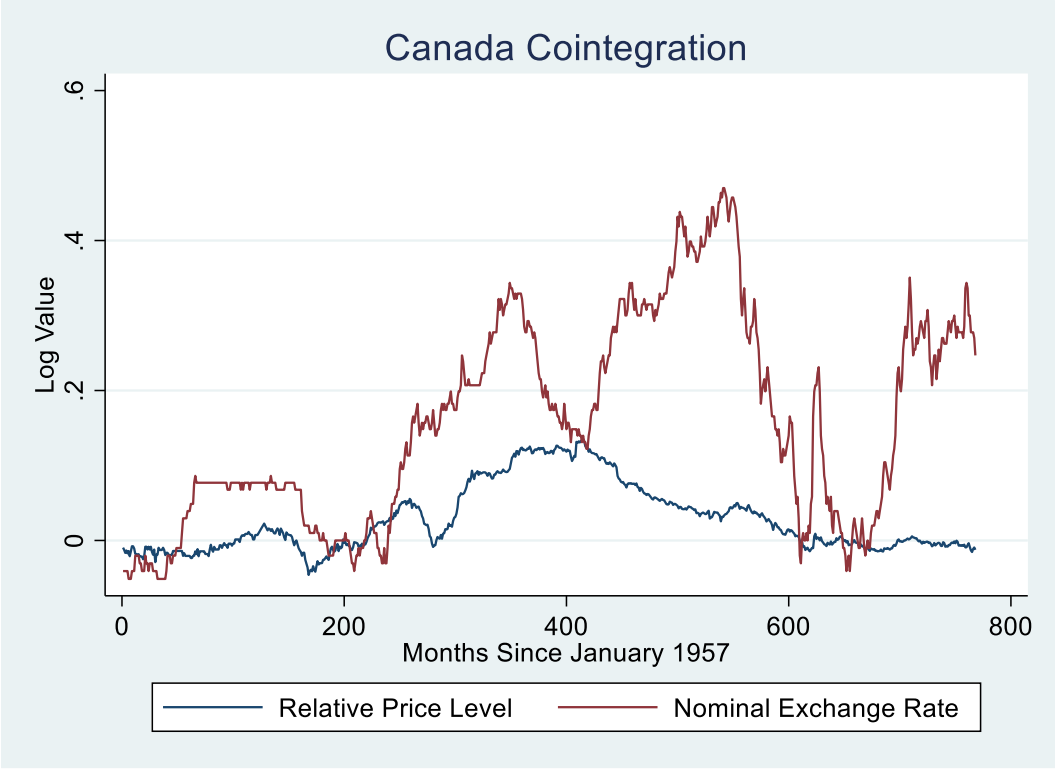
Visual Discussion

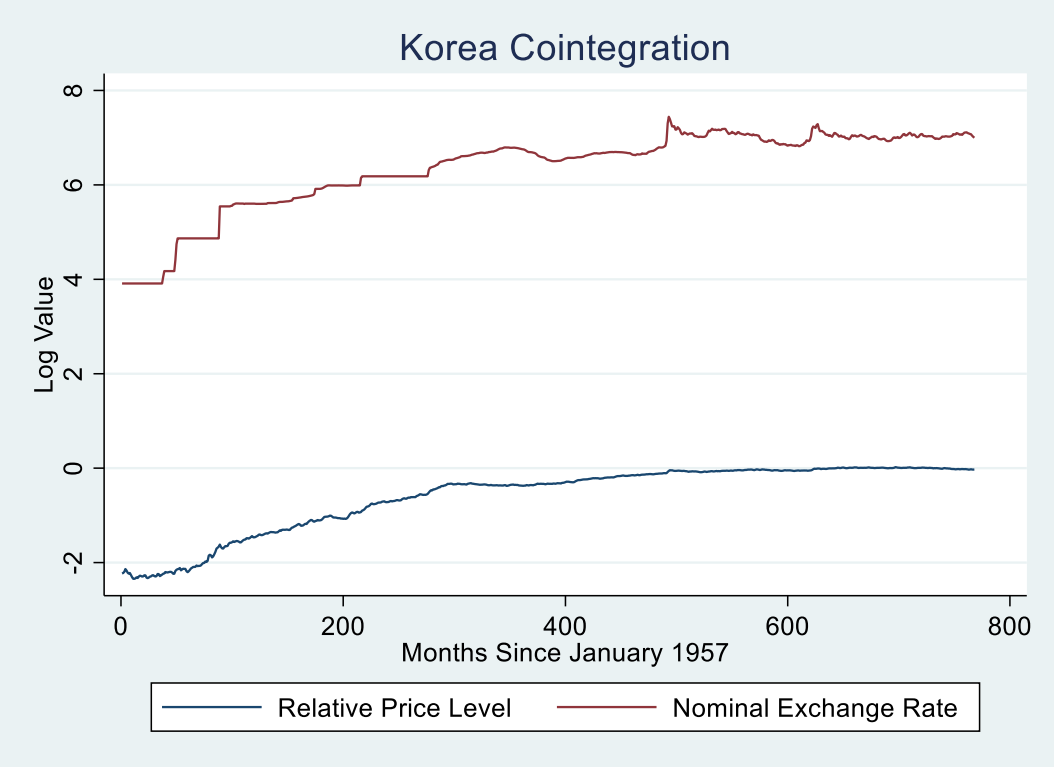
In order to analyze each country visually, I plotted each variable of note as a function of time. To view stationarity, the REER was plotted for each OECD country and Euro-data appendage. Those countries who seem to display the most stationarity within their time trends would be the countries that visibly give evidence in support of relative PPP. I also plotted both the log of the bilateral nominal exchange rate (σ_t) as well as the log of relative price levels (κ_t) as separate time trends. Cointegration between the two variables should appear visually as two trends whose movements appear to be in concert. Although a full compendium for each of the monthly 57 trends can be found in the appendix, I will highlight the observed trends for both Canada and Korea here.


Canada REER
Canada REER
.8
1
1.2
1.4
1.6
0
200
400
600
800
Months Since January 1957


Korea REER
Korea REER
500
1000
1500
2000
0
200
400
600
800
Months Since January 1957

Again, these graphs should be analyzed to look for any signs of stationarity in the REER over time. My concern is relative PPP, not absolute PPP would dictate that the REER for both countries stay firmly anchored at a value of one for each time period. Oddly enough, however, Canada seems to visually show signs for absolute PPP. Further tests would be needed to prove this conclusively. In regards to relative PPP however, an argument could certainly be made for the presence of REER stationarity in both. Although rather subjective visually, neither trend looks excessively stochastic and could be considered relatively stable. The Korean REER could potentially be approaching an equilibrium value of 1250 while the Canadian REER seems like it could potentially have a long run equilibrium of 1.2. Of course, observed stationarity is only one visual aspect which could serve as evidence of relative PPP. Observed cointegration between the variables could also suggest some form of relative PPP. I again highlight Canada and Korea for closer inspection.





Visually, there is a staunch difference between the two graphs above. The Korean trends seem to be moving in perfect unison. Any significant deviations seem to be exhibited by each trend and, although nonstationary, a combination of the trends could potentially create a stationary trend. Canada, on the other hand, seems to have two time series which are neither correlated or cointegrated. Significant deviations are not exhibited by both trends at the same time and they certainly do not appear to move in concert. Thus, from simply graphing the metrics used in both the ADF and Johansen tests, I can reasonably expect that Korea would show more evidence in support of relative PPP as opposed to Canada. However, everything that can really be said about the visualization of the data is subjective. Stronger statistical proof is needed to make any objective claims in relation to relative PPP. Thus, an analysis of the critical values produced in testing is necessary.

Statistical Discussion

I analyzed data for each country across three different period types: annual data, quarterly data, and monthly data. Given that as the data progresses from annual to monthly there becomes more observations available, I expect my results to become concurrently more robust due to the fact that monthly data allows for greater degrees of freedom. Thus, more credence will be given to the monthly data results. However, observations across each different type of period measurement were analyzed to see any changes in significance.

It is also important to note that due to a lack of observations, some data could not be analyzed for every period. Specifically, the Slovak Republic and Slovenia are dropped from monthly ADF testing and Estonia, Latvia, Lithuania, the Slovak Republic, and Slovenia are dropped from the Johansen tests. This is due to a lack of the degrees of freedom needed to run annual tests for both ADF and Johansen methods with optimal lags. New Zealand is also dropped entirely from any monthly testing due to the fact that no monthly data is available from the selected source.

The results of these tests are displayed in the table below. A significant ADF test statistic indicates evidence for stationarity in the REER time trend while a Johansen vector rank of 1 indicates evidence for cointegration between relative price level and bilateral nominal exchange rate. Although each individually provides evidence for relative PPP, a combination of both is more compelling in providing evidence for relative PPP. The bolded results in the following tables represent countries where any evidence in support of relative PPP is present. Unless an alternative end date is stipulated, an end date of 2020 was used for each time test.

Annual Data			
Country Name	Start Date	ADF Test Statistic	Johansen Vector Rank
Australia	**1950**	**-2.810***	**0**
Austria	1950-1998	-1.120	0
Austria (EU)	1950	-0.562	0
Belgium	1950-1998	-2.308	0
Belgium (EU)	1950	-0.616	0
Canada	1950	-2.156	0
Chile	**1973**	**4.440*****	**1**
Colombia	1950	-2.166	0
Costa Rica	1950	-1.600	0
Czech Republic	**1993**	**-1.609**	**1**
Denmark	1950	-2.176	0
Estonia	1992-2010	0.000	-
Estonia (EU)	1992	-0.949	0
Finland	**1950-1998**	**-2.416**	**1**
Finland (EU)	**1950**	**-0.815**	**1**
France	**1950-1998**	**-2.820***	**0**
France (EU)	**1950**	**-0.751**	**1**
Germany	1950-1998	-0.861	0
Germany (EU)	1950	-1.369	0
Greece	**1950-2000**	**-3.321****	**0**
Greece (EU)	1950	-0.549	1
Hungary	1972	-1.454	0
Iceland	**1950**	**-2.624***	**0**
Ireland	1950-1998	-1.399	0
Ireland (EU)	**1950**	**-2.765***	**0**
Israel	**1980**	**-2.539**	**1**
Italy	1950-1998	-2.035	0
Italy (EU)	1950	-0.636	0
Japan	1955	-1.979	0
Korea	**1952**	**4.639*****	**1**
Latvia	1992-2013	-1.901	-
Latvia (EU)	**1992**	**-2.634***	**1**
Lithuania	1992-2014	-1.388	-
Lithuania (EU)	1992	-1.602	0
Luxembourg	**1950-1998**	**-2.702***	**0**
Luxembourg (EU)	1950	-0.622	0
Mexico	**1950**	**-3.603****	**0**
Netherlands	1950-1998	-1.680	0
Netherlands (EU)	1950	-1.080	0
New Zealand	**1950**	**-2.991****	**0**
Norway	**1950**	**-2.156**	**1**
Poland	**1981**	**-1.104**	**1**
Portugal	1950-1998	-1.389	0
Portugal (EU)	1950	-0.576	0
Slovak Republic	1993-2008	-	-
Slovak Republic (EU)	1993	-0.790	0

Slovenia	1991-2006	-	-
Slovenia (EU)	**1991**	**-0.930**	**1**
Spain	1950-1998	-1.051	0
Spain (EU)	1950	-6.02	0
Sweden	1950	-2.146	0
Switzerland	1950	-1.434	0
Turkey	1992	-0.705	0
United Kingdom	**1955**	**-2.966****	**0**

Annual Results

Quarterly Data			
Country Name	Start Date	ADF Test Statistic	Johansen Vector Rank
Australia	**1957Q1**	**-2.905****	**0**
Austria	1957Q1-1998Q4	-1.666	0
Austria (EU)	1957Q1	-0.771	0
Belgium	1957Q1-1998Q4	-2.375	0
Belgium (EU)	**1957Q1**	**-0.748**	**1**
Canada	1957Q1	-2.106	0
Chile	1970Q1	-1.812	0
Colombia	**1957Q1**	**-1.624**	**1**
Costa Rica	**1974Q4**	**-2.040**	**1**
Czech Republic	**1991Q4**	**-1.712**	**1**
Denmark	1957Q1	-2.497	0
Estonia	**1992Q1-2010Q4**	**-2.042**	**1**
Estonia (EU)	**1992Q1**	**-1.059**	**1**
Finland	**1957Q1-1998Q4**	**-2.771***	**0**
Finland (EU)	1957Q1	-0.904	0
France	1957Q1-1998Q4	-2.364	0
France (EU)	1957Q1	-0.878	0
Germany	1957Q1-1998Q4	-1.197	0
Germany (EU)	1957Q1	-1.693	0
Greece	1957Q1-2000Q4	-2.569	0
Greece (EU)	**1957Q1**	**-0.666**	**1**
Hungary	1976Q1	-1.255	0
Iceland	**1957Q1**	**-4.868*****	**0**
Ireland	1957Q1-1998Q4	-2.114	0
Ireland (EU)	1957Q1	-2.466	0
Israel	**1980Q3**	**-2.645***	**1**
Italy	**1957Q1-1998Q4**	**-2.793***	**0**
Italy (EU)	1957Q1	-0.737	0
Japan	1957Q1	-2.208	0
Korea	**1957Q1**	**-3.912*****	**1**
Latvia	**1992Q2-2013Q4**	**-3.075****	**1**
Latvia (EU)	**1992Q2**	**-3.294****	**1**

Lithuania	**1992Q3-2014Q4**	**-1.733**	**1**
Lithuania (EU)	**1992Q3**	**-2.839***	**0**
Luxembourg	**1957Q1-1998Q4**	**-2.623***	**0**
Luxembourg (EU)	1957Q1	-0.744	1
Mexico	**1957Q1**	**-2.992****	**0**
Netherlands	1957Q1-1998Q4	-1.683	0
Netherlands (EU)	1957Q1	-1.241	0
New Zealand	**1957Q1**	**-3.121****	**0**
Norway	1957Q1	-2.288	0
Poland	**1981Q3**	**-2.359**	**1**
Portugal	1957Q1-1998Q4	-1.528	0
Portugal (EU)	**1957Q1**	**-0.712**	**1**
Slovak Republic	**1993Q1-2008Q4**	**-0.063**	**1**
Slovak Republic (EU)	1993Q1	-0.774	0
Slovenia	**1992Q1-2006Q4**	**-1.932**	**1**
Slovenia (EU)	**1992Q1**	**-0.967**	**1**
Spain	1957Q1-1998Q4	-1.725	0
Spain (EU)	1957Q1	-0.716	0
Sweden	**1957Q1**	**-2.697***	**0**
Switzerland	1957Q1	-1.881	0
Turkey	**1957Q1**	**1.885**	**1**
United Kingdom	**1957Q1**	**-3.205****	**0**

Quarterly Results

Monthly Data			
Country Name	Start Date	ADF Test Statistic	Johansen Vector Rank
Australia	2001M1	-2.25	0
Austria	1957M1-1998M12	-1.488	0
Austria (EU)	1957M1-1998M13	-0.75	0
Belgium	1957M1-1998M14	-1.908	0
Belgium (EU)	1957M1	-0.749	0
Canada	1957M1	-2.128	0
Chile	**1973M04**	**-3.355****	**1**
Colombia	**1957M1**	**-3.772*****	**1**
Costa Rica	**1974M10**	**-2.761***	**0**
Czech Republic	**1993M1**	**-1.740**	**1**
Denmark	**1967M1**	**-2.588***	**0**
Estonia	**1992M06-2010M12**	**-2.958****	**1**
Estonia (EU)	**1992M06**	**-1.138**	**1**
Finland	**1957M1-1998M12**	**-2.244**	**1**
Finland (EU)	**1957M1**	**-0.901**	**1**
France	**1957M1-1998M12**	**-2.379**	**1**
France (EU)	**1957M1**	**-0.864**	**1**

Germany	1957M1-1998M12	-1.491	0
Germany (EU)	1957M1	-1.667	0
Greece	**1957M1-2000M12**	**-2.291**	**1**
Greece (EU)	**1957M1**	**-0.687**	**1**
Hungary	1976M1	-1.319	0
Iceland	**1957M1**	**-4.020*** **	**1**
Ireland	1975M11-1998M12	-2.287	0
Ireland (EU)	1975M11	-2.122	0
Israel	**1987M7**	**-3.356** **	**1**
Italy	1957M1-1998M12	-2.374	0
Italy (EU)	**1957M1**	**-0.740**	**1**
Japan	1957M1	-1.982	0
Korea	**1957M1**	**-4.351*** **	**1**
Latvia	**1992M02-2013M12**	**-3.062** **	**0**
Latvia (EU)	**1992M02**	**-7.598*** **	**1**
Lithuania	**1992M12-2014M12**	**-4.723*** **	**1**
Lithuania (EU)	**1992M12**	**-2.699***	**1**
Luxembourg	1957M1-1998M12	-2.096	0
Luxembourg (EU)	1957M1	-0.743	0
Mexico	**1957M1**	**-2.912** **	**0**
Netherlands	1957M1-1998M12	-1.784	0
Netherlands (EU)	1957M1	-1.237	0
New Zealand	-	-	-
Norway	1957M1	-2.312	0
Poland	**1988M1**	**-2.033**	**1**
Portugal	**1957M1-1998M12**	**-1.294**	**1**
Portugal (EU)	**1957M1**	**-0.709**	**1**
Slovak Republic	1993M1-2008M12	0.671	0
Slovak Republic (EU)	1993M1	-0.801	0
Slovenia	**1991M11-2007M02**	**-1.929**	**1**
Slovenia (EU)	1991M11	-0.973	0
Spain	**1957M1-1998M12**	**-1.388**	**1**
Spain (EU)	**1957M1**	**-0.708**	**1**
Sweden	1957M1	-2.237	0
Switzerland	1957M1	-1.753	0
Turkey	**1991M12**	**-2.646***	**1**
United Kingdom	**1957M1**	**-3.015** **	**1**

Monthly Results

Note: The symbols *,**,*** correspond to a 10%, 5%, and 1% level of significance. The Johansen Vector Rank indicates the degree of cointegration corresponding to a 5% significance level. Unless an end is indicated, observations always go until 2020 (annual), 2020Q4 (quarterly), or 2020M12 (monthly).

As indicated by the previous results, a majority of the country observations display evidence in support of relative PPP. Visually, our initial observations were supported. Canada showed no evidence in support of relative PPP in any of the time period types while Korea showed strong evidence across all three. In fact, 41 of the 54 different countries and European Union extensions displayed evidence for relative PPP across our three data periods. Thus, the relative PPP hypothesis is generally supported. Specifically, there are five countries which provide very strong evidence: Colombia, Iceland, Korea, Latvia (EU), and Lithuania. Each of these countries provide significant ADF test statistics at the 1% level as well as Johansen Vector Ranks of 1 for monthly observations. Although there were numerous other countries which displayed some evidence for PPP, the obvious next question is why these countries showed such strong evidence while others did not.

Relative purchasing power parity operates under the assumption that when bilateral nominal exchange rates are allowed to shift freely, such as in a floating exchange rate regime, market forces will dictate that they change in proportion to price level differentials between the two countries. However, many of our observations date back to the time of the Bretton Woods system which tied specific exchange rates to the price of gold as well as the United States Dollar. Post Bretton Woods, many currencies were converted to fiat currencies and exchange rates became free-floating, but before that many currency's exchange rates were fixed to changes in gold and the US dollar. Thus, the inclusion of these Bretton Woods era observations within our datasets could serve to alter our results. However, Bretton Woods era data was present for many of our countries, so that itself does not serve as a complete explanation for discrepancies between countries. A deeper look at the five countries which provide strong evidence may shed more light on the subject.

Our initial Korean visual example proved to be a particularly strong piece of evidence for relative PPP. However, Korea is not good example of market driven relative purchasing power parity. The Korean government tied its nominal exchange rate primarily to the US dollar until its change in the early 1980s. From then until the early 1990s, they tied their exchange rate to a market basket of currencies for other major trading partners with the goal of a stabilized REER. After that, they tweaked their design slightly to a market average rate system in which exchange rates were decided by the market, but kept within a specified range determined by interbank rates (Sang-Woo Nam & Se-Jong Kim, 1999). This hybrid exchange rate regime with a specific target of a stable REER would naturally show signs of relative PPP. However, in arguing market driven relative PPP, Korea serves as a poor example.

Lithuania and Latvia (EU) also serve as somewhat poor sources for further investigation. Each of these countries has very limited data in comparison to the rest as both broke apart from the USSR during the fall of the Soviet bloc. Both countries were also either fixed to the Euro or adopted the Euro for a large portion of their existence. Lithuania in particular pegged their exchange rate to the United States dollar for a majority of their pre-European Union and as such their results should be taken hesitantly. Thus, I am left with Columbia and Iceland.

Columbia's history of exchange rate regimes is somewhat mixed. From the 1960s to the early 1990s, Colombia adopted a crawling peg strategy. Officials would let nominal exchange rates fluctuate between a set range, but would adjust these ranges as time progressed. This method was done with the intention for stability in RER. However, during the mid 1990s Colombia adopted a much more free-floating exchange rate regime in which nominal exchange rates were given much more room to adapt to the market. Although, within that time frame it should be noted that the variation in Columbian RER has increased significantly

(Frenkel & Rapetti, 2010). Therefore, Colombia may not serve as the best evidence for relative PPP either.

Finally, I consider Iceland. Iceland is very similar to Colombia in that it too used set pegs as a guide for its nominal exchange rate policy. Up until the mid 1990s, Iceland adopted a primarily fixed exchange rate regime by using things such as the US dollar and weighted market basket of major trading partner currencies. However, after this point Iceland has adopted a free-floating exchange rate (Edwards, 2018).

Thus, for these five countries, our statistical tests worked perfectly in that they correctly identified the efforts by each country to create a stable REER. Unfortunately, fixing nominal exchange rates in order to reach that stable REER is a perversion of our market based relative PPP theory. Thus, it might be wiser to look at a country who still showed evidence for relative PPP without the considerable policy intervention utilized by the five aforementioned countries.

Consider the United Kingdom. The ADF test statistics are significant at the 5% level for each period while the Johansen vector rank is 1 for each period except annual. Thus, the UK provides relatively strong evidence for PPP. However, is this evidence due to manufactured nominal exchange rates or due to a floating market regime? Similar to most countries, the UK was anchored to the United States dollar and gold as a part of Bretton Woods in the period immediately following World War 2. However, the pound became untethered at the end of the Bretton Woods era, and since 1973 the UK has mostly adopted a free-floating exchange rate regime. Relative PPP would then suggest that over this time period, bilateral nominal exchange rates were allowed to change in response to the changing price level differentials between the United States and the UK. This result is also corroborated by Hanck (2009) lending more support to relative PPP.

As indicated by the data above, Mexico also seems to show moderate evidence in support of relative PPP. The history of the Mexican exchange rate regime during this time follows the expected conditions that would lead to relative PPP. Although Mexico used strategies similar to that of Colombia up through the 1980s. However, during the 1990s the peso adopted a mostly free-floating exchange rate (Frankel, Rapetti, 2010). Given that Mexico provided moderate evidence for relative PPP, the results would serve to support the theory as a whole.

A final country to be considered is New Zealand. Although monthly data was unavailable, the country still showed support for relative PPP in both the annual and quarterly data results. Since the second World War, monetary policy in New Zealand has relaxed from fixed exchange rate regimes to a free-floating system. Since 1985, the New Zealand exchange rate has been allowed to float freely and in that time frame REER has remained relatively stable (Sullivan, 2013). Thus, it is safe to say that the evidence provided by New Zealand strongly supports the relative PPP in a freely moving international market.

Although I have already discussed why some countries may have shown strong evidence in support for relative PPP, it would also be prudent to discuss some of the countries which showed absolutely no evidence. Recall the Balassa-Samuelson hypothesis referenced in the literature review. For those countries who experienced incredible growth in comparison to the United States, it is more likely that their REER will experience disequilibrium. As noted by Rogoff (1996), post second World War per-capita income growth by Japan far outpaced that of the United States. Theoretically, this would disrupt REER which corroborates the lack of evidence found in regards to Japan in this paper. Similar countries such as Belgium, Canada, or Switzerland could also be following the Balassa-Samuelson hypothesis in a similar manner to Japan.

A surprising result of the statistical tests was the fact that 12 of the 17 of Euro extensions showed evidence in support of relative PPP. One would expect that these countries would show no evidence of relative PPP given their inclusion in a monetary union for a duration of their time series. Visually, most countries show a severe change in the REER when adopting the Euro. Regardless, of that 12, 1 extension even displayed some form of evidence while their pre-Euro tests did not. It should be noted, however, that most of their evidence comes in the form of significant Johansen test results as opposed to significant ADF results. Perhaps the Johansen tests were less likely to account for that severe structural break than the ADF tests. Or, perhaps the stringent monetary and economic requirements applied to prospective EU members before their actual inclusion could lead to spurious results. Regardless, further study into each of those specific cases is needed to properly explain those results.

As evidenced in the previous discussions, conclusively proving the validity of relative PPP requires more than just a numerical analysis of REER. A more in-depth historical perspective is needed to see if relative PPP truly arises naturally within these countries, or if the countries artificially set nominal exchange rates in the name of stability for their RER. Regardless of this, the results included in this paper still provide significant evidence in support of relative PPP. The statistical tests conducted pinpoint 37 possible candidates for which relative PPP may be present, and therefore identify further avenues for research. Overall, relative PPP as an economic theory should be treated as inconclusive, but probable.

4. Implications and Limitations

The results presented within this paper provide credible evidence in support of relative PPP and the theory of purchasing power parity as a whole. Although a Big Mac may not be worth the exact same amount everywhere in the world, there is evidence to suggest that bilateral

nominal exchange rates adjust to price level differentials. Thus, assumptions of real effective exchange rate stability can be considered well-founded. This implies that policymakers and other interested parties can feel comfortable using the idea of a stable REER in their decision-making. Furthermore, the results imply a bolstering in the reliability of the notion that REER can be used as a good determinant of currency over or under valuation. However, much more can be done in the matter of unraveling the purchasing power parity puzzle.

The testing methods within this specific paper, while still robust, could potentially be improved. A usage of further cointegration and unit root tests could serve to provide stronger evidence on the subject of relative PPP. An inclusion of nonlinear testing methods could also provide a more thorough review of relative PPP. Similarly, further alterations can be made to the testing structure. Although my testing methodology did follow that of Bianco (2008) it did not follow it exactly. Specifically, Bianco accounts for structural breaks within the time series while this paper does not. An inclusion of these structural breaks may make my results more robust.

Another point of further research to consider would be a more thorough look at each of the 37 countries tested. Specifically, their nominal exchange rate regimes and how any policy interventions would have affected the REER over time. Although this paper takes a cursory look at the exchange rate regime histories of eight of the tested countries, a more in-depth analysis of those, along with the rest of the tested countries, could provide a better understanding of the results. Although the large number of countries analyzed gives a diverse set of evidence for PPP, it does not allow for specific country-level analysis.

Conversely, the expansion of my tested country set could also serve to shed more light on relative PPP. I chose to use only OECD member nations; perhaps a more diverse set of countries could reveal more about relative PPP. An inclusion of more of both developing and developed

nations would provide a more expansive view of the subject. Similarly, each REER generated and all of the calculations within the paper are done relative to the United States as both a comparative price level and nominal exchange rate. Diversifying from the United States as a basis for comparison could lead to surprising new results. In the same vein, my paper also uses CPI as a measure for national price level. Other options such as WPI or GDP deflators as indicators for national price levels could add to the results here.

Although each of these potential avenues for future research could serve to enhance my work, it is my hope that the results presented in this paper still serve to further the discourse on relative PPP. As evidenced by both my work and the work of those before me, there is still an enormous amount of opportunity associated with relative PPP research.

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Appendix A. Summary Statistics

Variable (source)	Description	Mean	Standard Dev.	Minimum	Maximum
United States CPI	Prices, Consumer Price Index, All items, Index, Annual Observations, 2010 Base Period	53.13254	36.26204	11.03	118.69
Australia CPI		48.85014	39.10888	4.55	120.81
Austria CPI		58.40817	34.40536	10.73	119.69
Belgium CPI		56.61169	35.2593	12.87	117.98
Canada CPI		54.75465	36.74566	10.72	117.59
Chile CPI		55.05039	45.59694	0	135.93
Colombia CPI		34.20817	46.62636	.03	144.51
Costa Rica CPI		30.61817	44.03443	.21	129.78
Czech Republic CPI		73.712	30.91291	23.95	108.64
Denmark CPI		52.3807	37.57844	5.97	110.81
Estonia CPI		82.28379	30.91698	11.64	122.14
Finland CPI		53.85113	39.06896	5.07	112.66
France CPI		54.46563	37.74154	5.97	110.57
Germany CPI		62.04352	30.98314	20.45	113.43
Greece CPI		37.62014	40.87934	.64	104.88
Hungary CPI		48.03163	44.96589	2.24	125.69
Iceland CPI		36.7738	43.31435	.02	132.68
Ireland CPI		49.06662	39.35924	3.51	106.58
Israel CPI		39.42072	43.9537	0	108.18
Italy CPI		47.18394	40.58446	3.01	110.62
Japan CPI		73.66061	33.3648	17.62	105.48
Korea CPI		45.25261	40.61848	.26	115.78
Latvia CPI		75.84233	32.98353	1.13	117.11
Lithuania CPI		80.60133	32.00853	.37	119.8
Luxembourg CPI		56.56634	34.37235	14.44	116.03
Mexico CPI		34.42254	47.07786	.01	146.35
Netherlands CPI		58.30746	34.15984	12.41	117.38
New Zealand CPI		47.86113	40.19238	3.22	116.2
Norway CPI		51.91648	38.55643	5.78	121.82
Poland CPI		47.88588	46.35831	.02	117.96
Portugal CPI		42.99197	42.84759	1.05	110.62
Slovak Republic CPI		80.71967	29.16738	26.12	117.57
Slovenia CPI		58.32073	43.37521	0	111.05
Spain CPI		45.19972	40.50686	1.73	110.96
Sweden CPI		53.04338	38.70188	5.83	111.06
Switzerland CPI		63.35662	30.06823	20.86	100.23
Turkey CPI		35.35294	63.30662	0	263.22
UK CPI		54.04606	39.43565	5.51	120.81
Australia Nominal Exchange Rate		1.127606	.2858344	.67	1.96

Austria Nominal Exchange Rate	Domestic Currency per U.S. Dollar, Annual Average	19.50429	5.936401	10.08	26
Austria (EU) Nominal Exchange Rate		13.72366	9.982908	.68	26
Belgium Nominal Exchange Rate		43.50714	8.241728	29.24	59.38
Belgium (EU) Nominal Exchange Rate		30.28901	21.00686	.68	59.38
Canada Nominal Exchange Rate		1.166197	.1655585	.96	1.57
Chile Nominal Exchange Rate		254.3944	265.8785	0	792.73
Colombia Nominal Exchange Rate		891.5018	1110.677	1.96	3694.85
Costa Rica Nominal Exchange Rate		181.6321	218.5995	5.62	587.29
Czech Republic Nominal Exchange Rate		25.48	5.964948	17.07	38.6
Denmark Nominal Exchange Rate		6.727324	1.021504	5.1	10.6
Estonia Nominal Exchange Rate		13.11316	1.997226	10.64	17.69
Estonia (EU) Nominal Exchange Rate		8.877931	6.153351	.72	17.69
Finland Nominal Exchange Rate		3.884694	1.022285	2.3	6.2
Finland (EU) Nominal Exchange Rate		2.943944	1.649342	.68	6.2
France Nominal Exchange Rate		5.129796	1.210891	3.5	8.99
France (EU) Nominal Exchange Rate		3.803239	2.232771	.68	8.99
Germany Nominal Exchange Rate		2.977347	1.058794	1.43	4.2
Germany (EU) Nominal Exchange Rate		2.317746	1.325133	.68	4.2
Greece Nominal Exchange Rate		91.74216	93.52078	15	365.4
Greece (EU) Nominal Exchange Rate		66.1338	89.12571	.68	365.4
Hungary Nominal Exchange Rate		139.3264	94.53864	32.53	308
Iceland Nominal Exchange Rate		44.14239	46.15405	.16	135.42
Ireland Nominal Exchange Rate		.5104082	.1632733	.36	.95

Ireland (EU) Nominal Exchange Rate		.6152113	.2179112	.36	1.12
Israel Nominal Exchange Rate		1.70831	1.816846	0	4.74
Italy Nominal Exchange Rate		960.4782	425.2842	583	1909.44
Italy (EU) Nominal Exchange Rate		663.1282	569.0035	.68	1909.44
Japan Nominal Exchange Rate		218.1535	110.9327	79.79	361.1
Korea Nominal Exchange Rate		659.6938	425.2492	2.5	1403.18
Latvia Nominal Exchange Rate		.5690909	.0603884	.48	.74
Latvia (EU) Nominal Exchange Rate		.6406896	.1415711	.48	.9
Lithuania Nominal Exchange Rate		3.194348	.7621431	1.77	4.34
Lithuania (EU) Nominal Exchange Rate		2.716552	1.167397	.85	4.34
Luxembourg Nominal Exchange Rate		43.50714	8.241728	29.24	59.38
Luxembourg (EU) Nominal Exchange Rate		30.28901	21.00686	.68	59.38
Mexico Nominal Exchange Rate		4.921127	6.373843	.01	21.49
Netherlands Nominal Exchange Rate		2.92898	.8005265	1.61	3.8
Netherlands (EU) Nominal Exchange Rate		2.284366	1.175814	.68	3.8
New Zealand Nominal Exchange Rate		1.247465	.4614936	.71	2.38
Norway Nominal Exchange Rate		6.890282	.9704756	4.94	9.42
Poland Nominal Exchange Rate		1.36169	1.656302	0	4.35
Portugal Nominal Exchange Rate		71.75735	57.89672	24.52	180.1
Portugal (EU) Nominal Exchange Rate		49.78563	58.21623	.68	180.1
Slovak Republic Nominal Exchange Rate		34.30625	7.580664	21.36	48.35
Slovak Republic (EU) Nominal Exchange Rate		19.95286	17.79874	.72	48.35
Slovenia Nominal Exchange Rate		162.5794	58.95743	27.57	242.75

Slovenia (EU) Nominal Exchange Rate		87.082	92.39408	.68	242.75
Spain Nominal Exchange Rate		82.8251	37.84645	38.95	170.04
Spain (EU) Nominal Exchange Rate		57.42394	49.39431	.68	170.04
Sweden Nominal Exchange Rate		6.386761	1.57245	4.15	10.33
Switzerland Nominal Exchange Rate		2.445352	1.397253	.89	4.37
Turkey Nominal Exchange Rate		.9861972	1.490004	0	7.01
UK Nominal Exchange Rate		.5325352	.1367136	.36	.78
United States CPI	Prices, Consumer Price Index, All items, Index, Quarterly Observations, 2010 Base Period	57.62449	35.19525	12.7	119.4
Australia CPI		53.50707	38.19725	7.39	121.96
Austria CPI		63.17191	32.68798	16.12	120.49
Belgium CPI		61.26051	33.8424	15.03	118.07
Canada CPI		59.44246	35.48642	12.54	118.09
Chile CPI		55.05039	45.27249	0	137.45
Colombia CPI		37.94578	47.38623	.04	144.78
Costa Rica CPI		34.88462	45.18583	.24	130.23
Czech Republic CPI		85.87408	23.41951	32.32	120.8
Denmark CPI		57.35578	36.04012	7.86	111.1
Estonia CPI		82.28448	30.54915	5.59	123.05
Finland CPI		59.09168	37.37248	7.12	112.94
France CPI		59.60832	35.98705	7.98	110.8
Germany CPI		66.41121	29.32305	23.31	113.9
Greece CPI		41.64223	40.87647	1.05	105.89
Hungary CPI		52.09683	44.33951	2.57	126.64
Iceland CPI		40.79309	43.54988	.04	134.78
Ireland CPI		53.97895	38.15458	4.68	107.05
Israel CPI		42.50004	43.93496	0	108.62
Italy CPI		51.95617	39.71161	3.93	110.94
Japan CPI		75.4107	32.15705	17.99	105.96
Korea CPI		48.73816	39.89841	1.26	116.1
Latvia CPI		75.8425	32.60231	.81	117.7
Lithuania CPI		80.60275	31.64668	.2	119.93
Luxembourg CPI		61.03508	33.07909	16.58	116.35
Mexico CPI		38.18707	47.85533	.01	148.44
Netherlands CPI		63.1632	32.27406	15.61	118.17
New Zealand CPI		52.66332	39.23644	4.5	116.86
Norway CPI		56.7991	37.28112	8.28	122.52
Poland CPI		59.56061	44.02709	.03	118.38
Portugal CPI		47.57715	42.45289	1.1	111.49

Slovak Republic CPI		80.72033	28.80905	23.93	117.77
Slovenia CPI		58.32085	42.98921	0	111.71
Spain CPI		49.93496	39.67099	2.24	111.84
Sweden CPI		58.05742	37.26884	8.31	111.67
Switzerland CPI		67.85762	28.04663	23.17	100.96
Turkey CPI		37.56277	64.31273	0	278.54
UK CPI		55.55785	38.86287	5.91	121.21
Australia Nominal Exchange Rate	Domestic Currency per U.S. Dollar, Quarterly Average	1.151328	.2903612	.67	1.95
Austria Nominal Exchange Rate		18.82292	6.049703	9.82	26
Austria (EU) Nominal Exchange Rate		12.64461	9.855578	.64	26
Belgium Nominal Exchange Rate		42.42494	8.487977	28.44	65.37
Belgium (EU) Nominal Exchange Rate		28.13344	20.94381	.64	65.37
Canada Nominal Exchange Rate		1.183125	.1652888	.95	1.59
Chile Nominal Exchange Rate		282.2181	264.6785	0	823.26
Colombia Nominal Exchange Rate		988.7464	1124.133	2.51	3849.38
Costa Rica Nominal Exchange Rate		200.8834	220.7734	5.62	606.65
Czech Republic Nominal Exchange Rate		25.47964	5.979824	15.89	40.18
Denmark C Nominal Exchange Rate		6.708047	1.095537	4.78	11.64
Estonia Nominal Exchange Rate		13.23573	2.039885	9.89	18.47
Estonia (EU) Nominal Exchange Rate		8.921304	6.157184	.69	18.47
Finland Nominal Exchange Rate		4.148571	.8617697	2.3	6.78
Finland (EU) Nominal Exchange Rate		3.01457	1.719337	.64	6.78
France Nominal Exchange Rate		5.401607	1.104024	3.5	9.96
France (EU) Nominal Exchange Rate		3.836875	2.34433	.64	9.96
Germany Nominal Exchange Rate		2.774524	1.00277	1.4	4.2
Germany (EU) Nominal Exchange Rate		2.112852	1.225867	.64	4.2

Greece Nominal Exchange Rate		02.6704	95.61378	28.5	391.42
Greece (EU) Nominal Exchange Rate		70.84641	92.25371	.64	391.42
Hungary Nominal Exchange Rate		139.3262	94.12299	32.02	319.6
Iceland Nominal Exchange Rate		48.95348	46.01942	.16	141.32
Ireland Nominal Exchange Rate		.5357143	.163753	.36	1.05
Ireland (EU) Nominal Exchange Rate		.6436328	.212135	.36	1.15
Israel Nominal Exchange Rate		1.894922	1.809752	0	4.88
Italy Nominal Exchange Rate		1016.4	433.3392	574.38	2021.09
Italy (EU) Nominal Exchange Rate		667.3048	597.1166	.64	2021.09
Japan Nominal Exchange Rate		202.5873	105.2891	77.4	360
Korea Nominal Exchange Rate		729.4959	387.5324	50	1611.71
Latvia Nominal Exchange Rate		.5662069	.0596548	.45	.82
Latvia (EU) Nominal Exchange Rate		.6393913	.1422519	.45	.94
Lithuania Nominal Exchange Rate		3.194783	.7748427	1.06	4.94
Lithuania (EU) Nominal Exchange Rate		2.717069	1.165202	.81	4.94
Luxembourg Nominal Exchange Rate		42.42494	8.487977	28.44	65.37
Luxembourg (EU) Nominal Exchange Rate		28.13344	20.94381	.64	65.37
Mexico Nominal Exchange Rate		5.457891	6.464389	.01	23.36
Netherlands Nominal Exchange Rate		2.783452	.7724794	1.56	3.8
Netherlands (EU) Nominal Exchange Rate		2.118711	1.114816	.64	3.8
New Zealand Nominal Exchange Rate		1.306562	.4514577	.69	2.44
Norway Nominal Exchange Rate		6.863281	1.041847	4.84	10.02
Poland Nominal Exchange Rate		1.51043	1.671637	0	4.5

Portugal Nominal Exchange Rate		78.92559	59.27905	22.99	186.18
Portugal (EU) Nominal Exchange Rate		52.08699	60.67837	.64	186.18
Slovak Republic Nominal Exchange Rate		34.30734	7.522503	20.11	49.4
Slovak Republic (EU) Nominal Exchange Rate		19.95393	17.58661	.68	49.4
Slovenia Nominal Exchange Rate		171.58	47.65382	71.87	254.57
Slovenia (EU) Nominal Exchange Rate		89.13466	92.25588	.64	254.57
Spain Nominal Exchange Rate		90.0672	36.0073	38.95	180.07
Spain (EU) Nominal Exchange Rate		59.39867	51.4952	.64	180.07
Sweden Nominal Exchange Rate		6.520039	1.614433	3.94	10.58
Switzerland Nominal Exchange Rate		2.234922	1.303262	.83	4.37
Turkey Nominal Exchange Rate		.7876953	1.435219	0	7.88
UK Nominal Exchange Rate		.551875	.1321066	.36	.9
United States CPI	Prices, Consumer Price Index, All items, Index, Monthly Observations, 2010 Base Period	57.62453	35.14994	12.66	119.45
Australia CPI		98.18196	14.52833	72.18	120.54
Austria CPI		63.17421	32.64302	16.12	121.01
Belgium CPI		61.26023	33.79909	15.02	118.24
Canada CPI		59.44293	35.44092	12.54	118.23
Chile CPI		55.05049	45.19931	0	137.7
Colombia CPI		37.94566	47.32511	.04	145.27
Costa Rica CPI		34.70122	45.07535	.24	130.69
Czech Republic CPI		85.87456	23.35615	30.6	121.05
Denmark CPI		66.27944	32.01773	11.65	111.42
Estonia CPI		82.28431	30.46466	3.35	123.39
Finland CPI		59.09139	37.32369	7.12	113.03
France CPI		59.60852	35.94063	7.96	111.06
Germany CPI		66.41281	29.28593	23.22	114.29
Greece CPI		41.64193	40.82547	1.04	106.33
Hungary CPI		52.09698	44.2579	2.57	126.8
Iceland CPI		40.7929	43.49379	.04	134.99
Ireland CPI		73.43153	27.70289	15.49	107.3
Israel CPI		42.50029	43.87838	0	109.09
Italy CPI		51.95605	39.66012	3.93	111.3
Japan CPI		75.41116	32.1161	17.94	105.99

Korea CPI		48.73806	39.84725	1.25	116.64
Latvia CPI		75.84267	32.51474	.73	117.99
Lithuania CPI		80.37917	31.80151	.17	120
Luxembourg CPI		61.03534	33.03726	16.54	116.55
Mexico CPI		38.1868	47.79371	.01	148.86
Netherlands CPI		63.16439	32.23163	15.53	118.67
New Zealand CPI					
Norway CPI		56.79896	37.23352	8.25	122.92
Poland CPI		73.97366	36.50293	.25	118.47
Portugal CPI		47.57734	42.39822	1.09	111.67
Slovak Republic CPI		80.72033	28.72939	22.17	117.81
Slovenia CPI		58.32116	42.9033	0	112.23
Spain CPI		49.93488	39.61948	2.23	111.93
Sweden CPI		58.05727	37.22095	8.31	112.19
Switzerland CPI		67.85759	28.01047	23.12	101.05
Turkey CPI		37.56281	64.23323	0	282.97
UK CPI		55.55797	38.8125	5.9	121.4
Australia Nominal Exchange Rate	Domestic Currency per U.S. Dollar, Monthly Average	1.15138	.2911465	.67	2
Austria Nominal Exchange Rate		18.82294	6.042374	9.71	26
Austria (EU) Nominal Exchange Rate		12.6447	9.844533	.63	26
Belgium Nominal Exchange Rate		42.42518	8.49277	27.98	66.53
Belgium (EU) Nominal Exchange Rate		28.13367	20.92226	.63	66.53
Canada Nominal Exchange Rate		1.183464	.1658284	.95	1.6
Chile Nominal Exchange Rate		282.218	264.4198	0	853.38
Colombia Nominal Exchange Rate		988.7462	1123.269	2.51	3986.56
Costa Rica Nominal Exchange Rate		200.8835	220.4992	5.62	611.37
Czech Republic Nominal Exchange Rate		25.47988	5.983813	14.92	41.13
Denmark C Nominal Exchange Rate		6.707682	1.099431	4.73	11.83
Estonia Nominal Exchange Rate		13.30049	2.012365	9.92	18.32
Estonia (EU) Nominal Exchange Rate		8.938134	6.172388	.69	18.32
Finland Nominal Exchange Rate		4.148512	.8621596	2.3	6.85

Finland (EU) Nominal Exchange Rate		3.014609	1.717679	.63	6.85
France Nominal Exchange Rate		5.401171	1.105134	3.5	10.11
France (EU) Nominal Exchange Rate		3.836667	2.342015	.63	10.11
Germany Nominal Exchange Rate		2.774524	1.00145	1.38	4.2
Germany (EU) Nominal Exchange Rate		2.11293	1.224575	.63	4.2
Greece Nominal Exchange Rate		102.6704	95.46617	28.07	397.35
Greece (EU) Nominal Exchange Rate		70.84641	92.15751	.63	397.35
Hungary Nominal Exchange Rate		139.3264	94.03194	31.79	328.07
Iceland Nominal Exchange Rate		48.95346	45.98017	.16	144.45
Ireland Nominal Exchange Rate		.5356349	.1636706	.36	1.06
Ireland (EU) Nominal Exchange Rate		.6436589	.2122292	.36	1.17
Israel Nominal Exchange Rate		1.894909	1.807614	0	4.94
Italy Nominal Exchange Rate		1016.4	432.867	564.45	2083.67
Italy (EU) Nominal Exchange Rate		667.3049	596.5232	.63	2083.67
Japan Nominal Exchange Rate		202.5875	105.1894	76.77	360
Korea Nominal Exchange Rate		729.496	387.5442	50	1706.8
Latvia Nominal Exchange Rate		.5654373	.0607248	.45	.84
Latvia (EU) Nominal Exchange Rate		.6382421	.1421555	.45	.95
Lithuania Nominal Exchange Rate		3.258981	.707903	2.19	5.14
Lithuania (EU) Nominal Exchange Rate		2.75178	1.159147	.81	5.14
Luxembourg Nominal Exchange Rate		42.42518	8.49277	27.98	66.53
Luxembourg (EU) Nominal Exchange Rate		28.13367	20.92226	.63	66.53
Mexico Nominal Exchange Rate		5.45793	6.458801	.01	24.26

Netherlands Nominal Exchange Rate		2.783591	.7715487	1.55	3.8
Netherlands (EU) Nominal Exchange Rate		2.11888	1.11363	.63	3.8
New Zealand Nominal Exchange Rate					
Norway Nominal Exchange Rate		6.863125	1.046177	4.82	10.44
Poland Nominal Exchange Rate		1.510547	1.670223	0	4.64
Portugal Nominal Exchange Rate		78.92583	59.18451	22.32	186.93
Portugal (EU) Nominal Exchange Rate		52.08723	60.61422	.63	186.93
Slovak Republic Nominal Exchange Rate		34.30766	7.509501	19.22	50.96
Slovak Republic (EU) Nominal Exchange Rate		19.95402	17.54073	.67	50.96
Slovenia Nominal Exchange Rate		170.4559	48.54701	53.39	256.6
Slovenia (EU) Nominal Exchange Rate		89.99086	91.83174	.63	256.6
Spain Nominal Exchange Rate		90.06762	35.97308	38.95	183.26
Spain (EU) Nominal Exchange Rate		59.39902	51.44526	.63	183.26
Sweden Nominal Exchange Rate		6.519961	1.616063	3.92	10.78
Switzerland Nominal Exchange Rate		2.234753	1.301844	.78	4.37
Turkey Nominal Exchange Rate		.7850326	1.435798	0	7.98
UK Nominal Exchange Rate		.5519141	.1321909	.36	.91

All data comes from International Monetary Fund (IMF) International Financial Statistics

Appendix B. STATA Commands

Both ADF and Johansen testing methods are available on STATA. The syntax “dfuller” with log of REER (τ_t) as the argument performs an ADF test on our REER variable. In this case, a validation of PPP would require a rejection of the null hypothesis. To test for cointegration, we use the syntax “vecrank” with log of nominal exchange rate (κ_t) and log of relative price levels (σ_t) as the main arguments. The syntax also requires a lag, which we generate in the same manner as our ADF tests by using AIC. The syntax itself actually performs both types of Johansen tests, the trace and maximum eigenvalue tests, and determines the number of cointegrating equations using a method which combines both testing type results. To support cointegration, and validate PPP, the command must imply the existence of a rank order 1.

Appendix C. Visual Results

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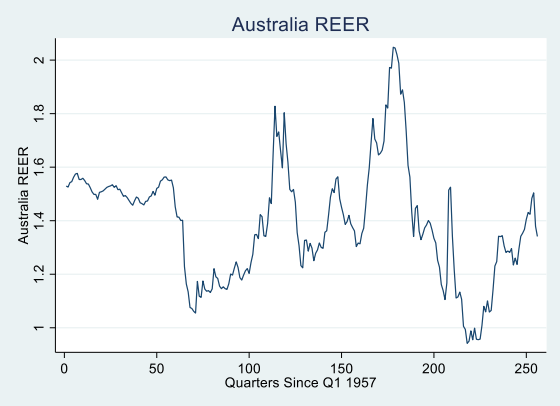
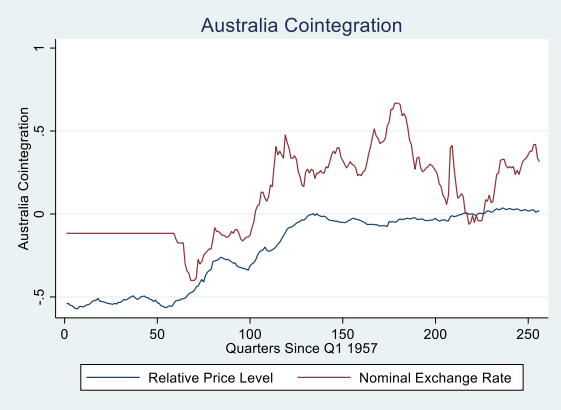
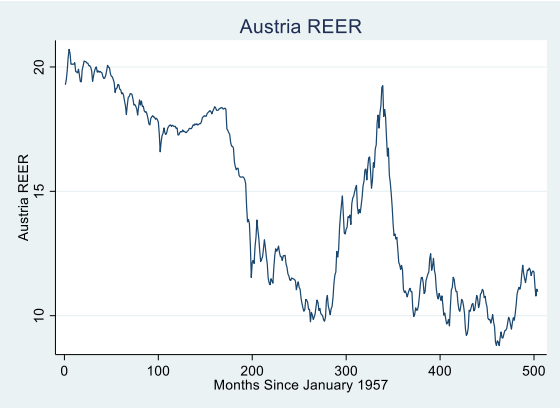
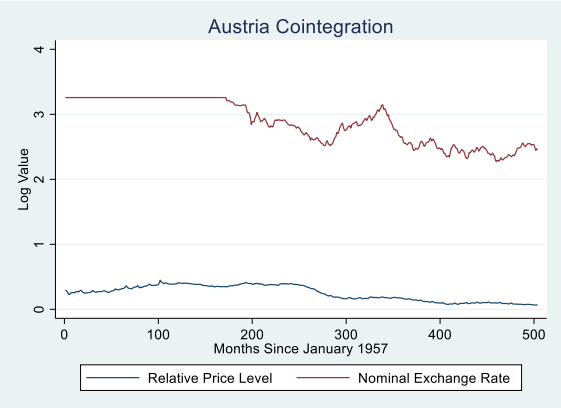




Austria





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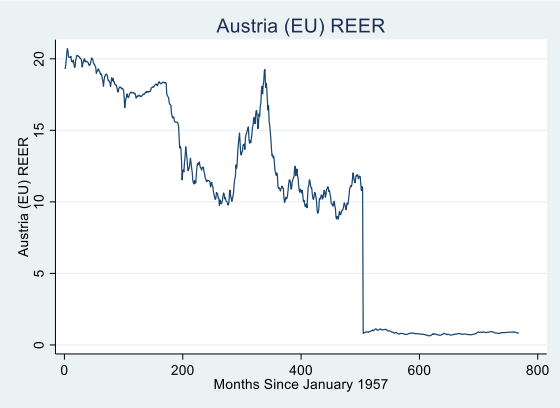
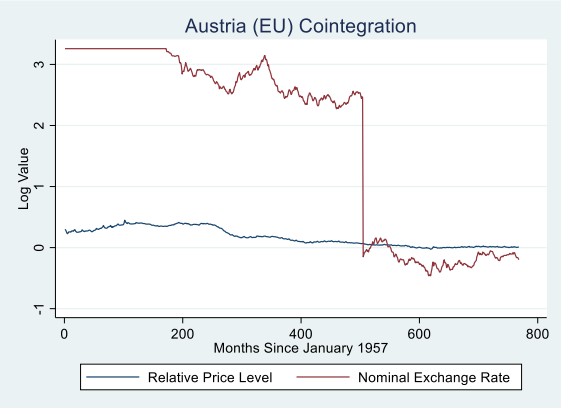
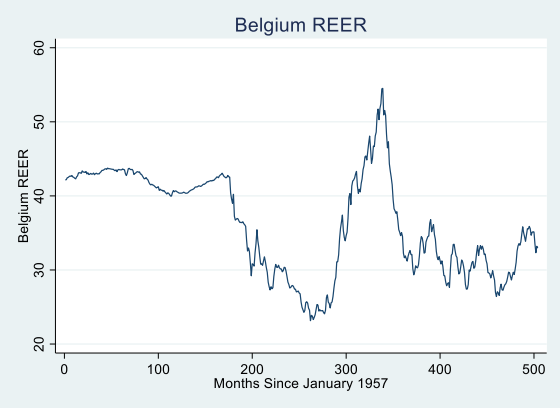
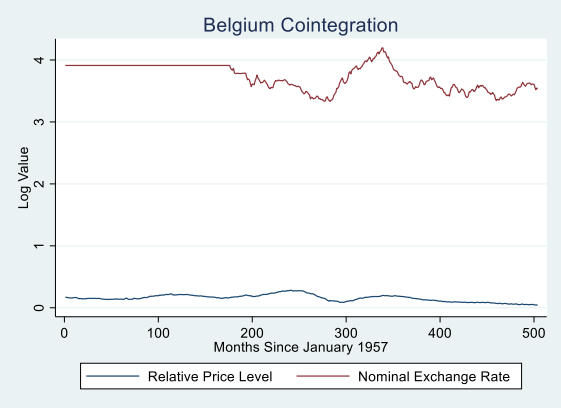




Belgium





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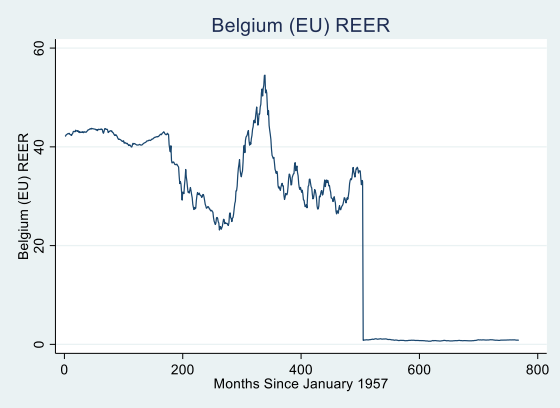

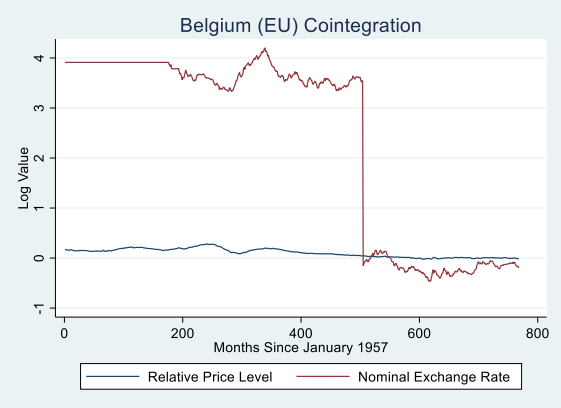

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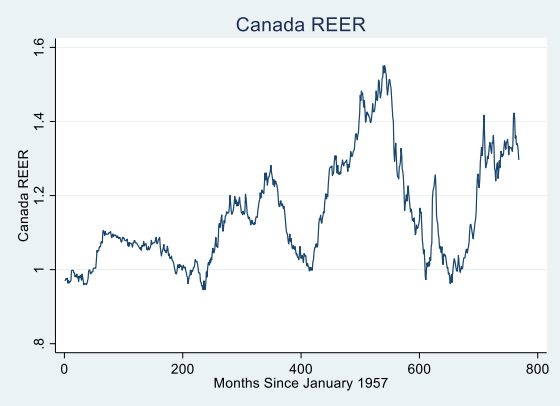

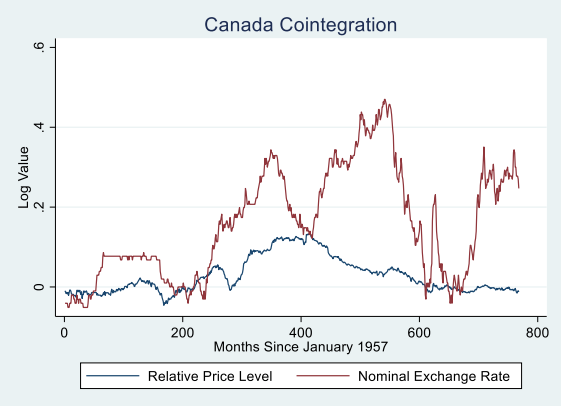

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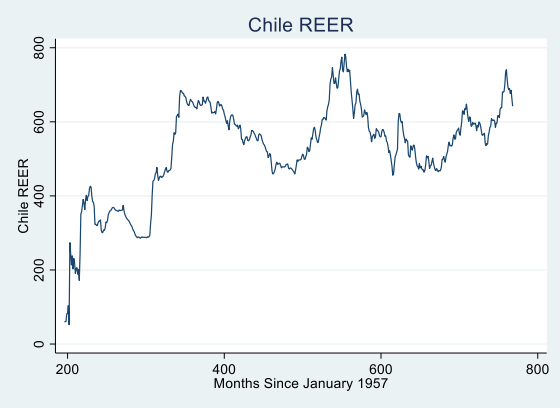

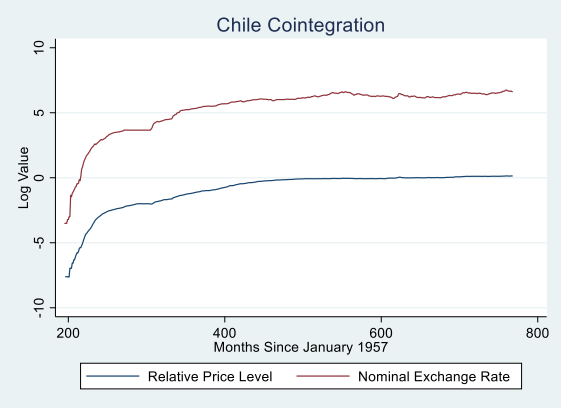

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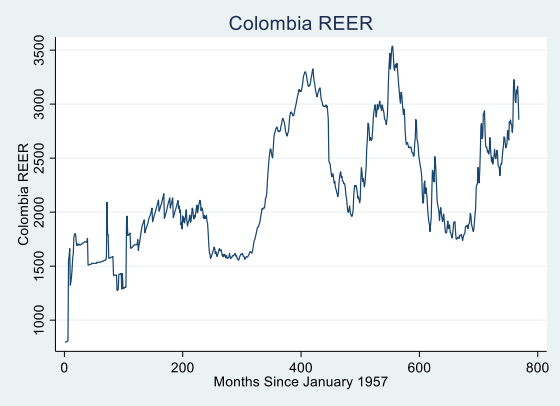
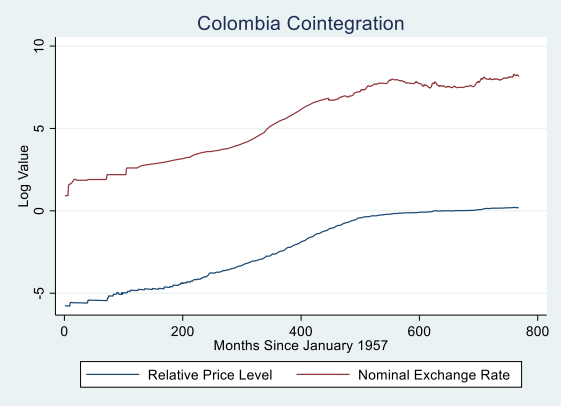
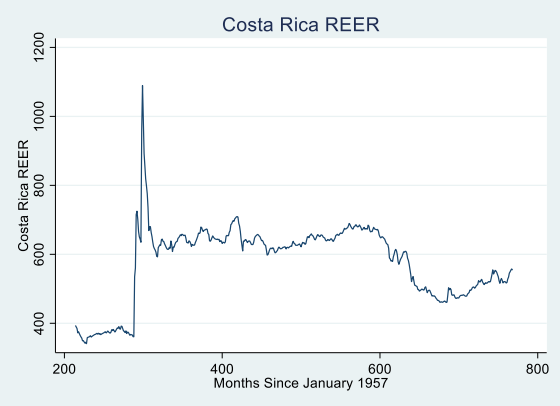
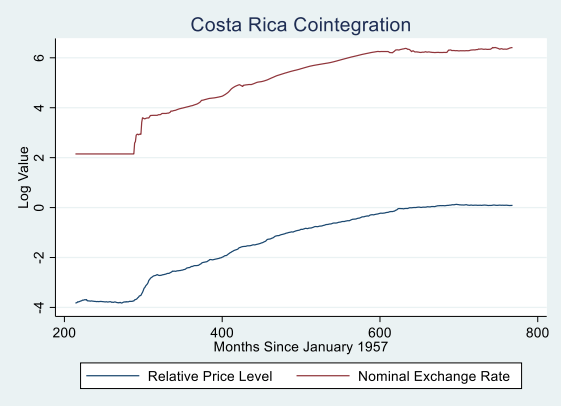




Costa Rica





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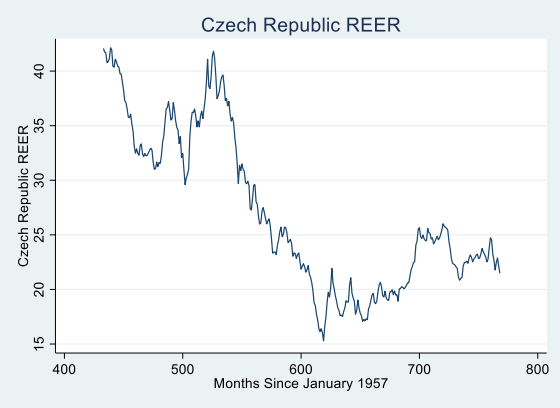

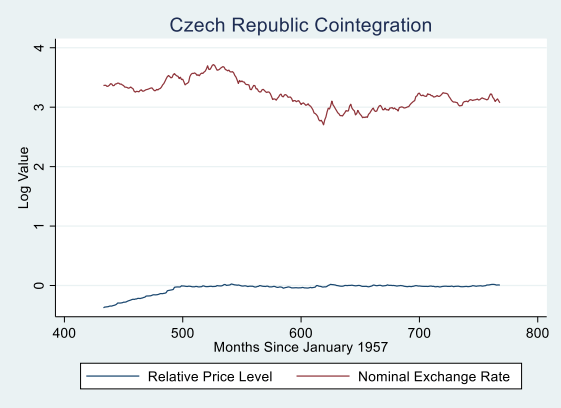

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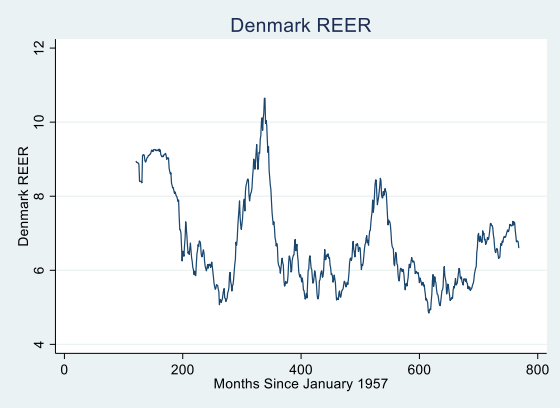

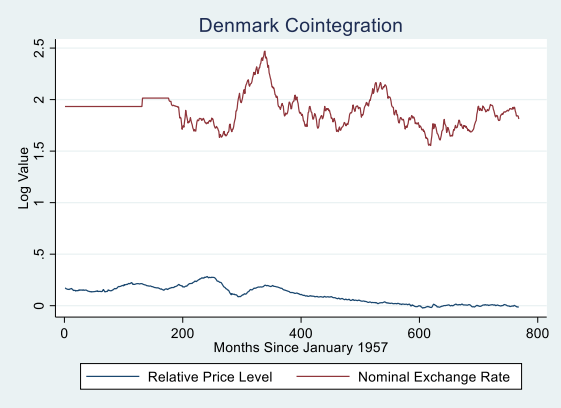

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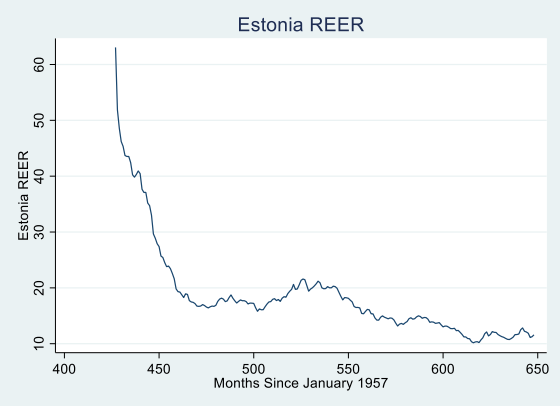

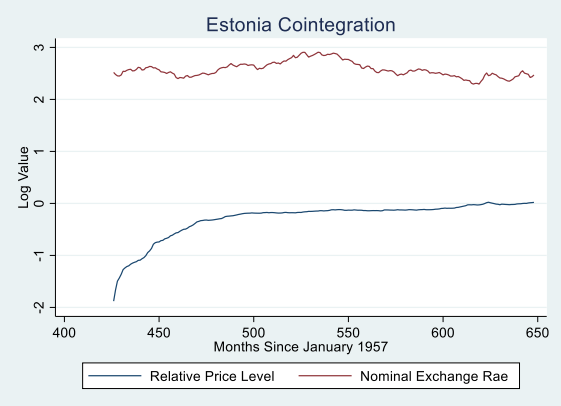

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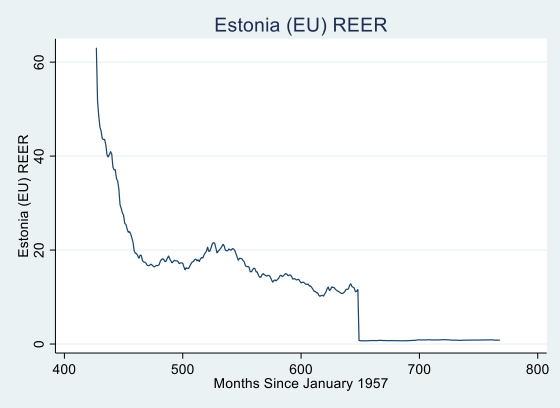

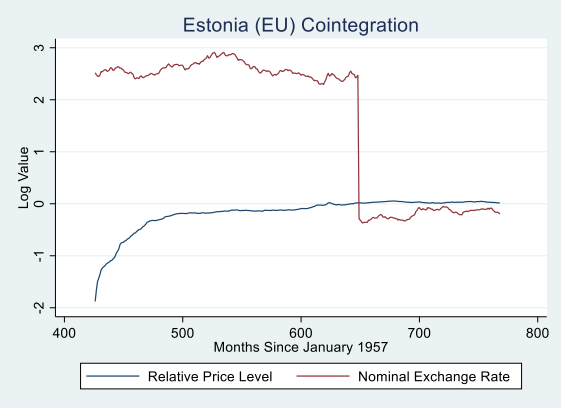

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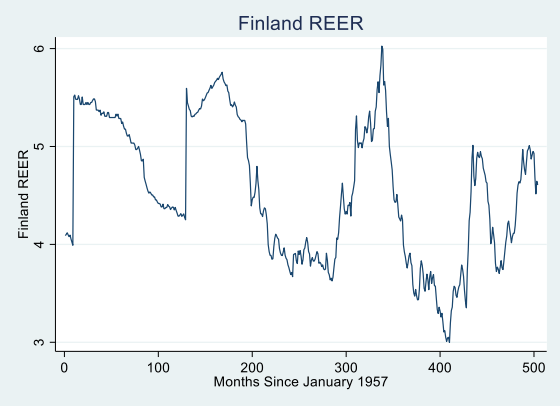

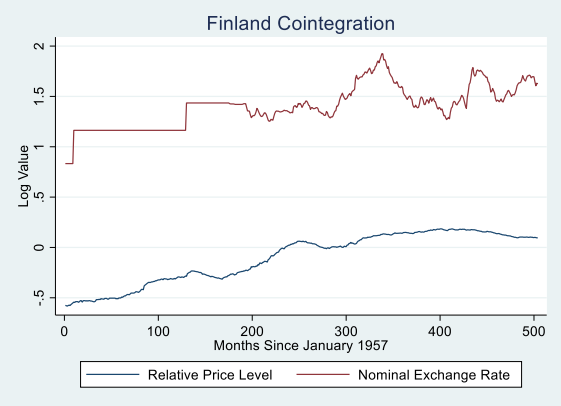

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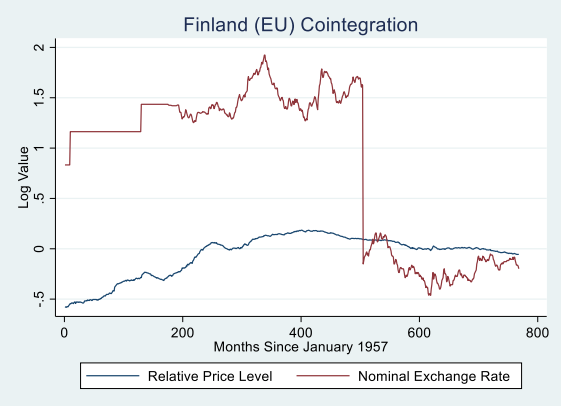

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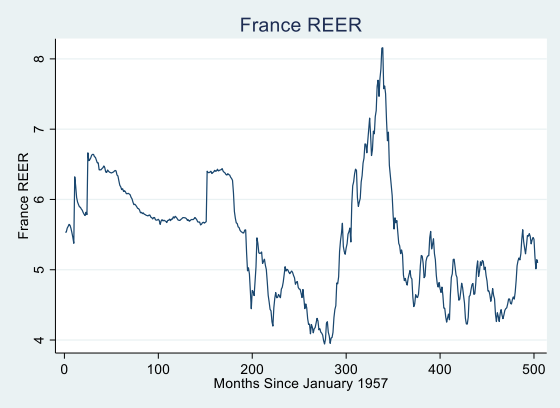

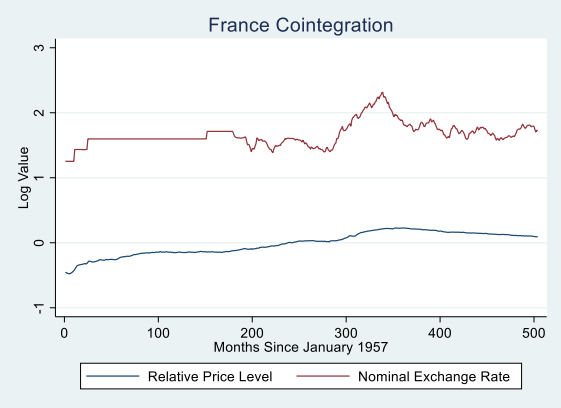

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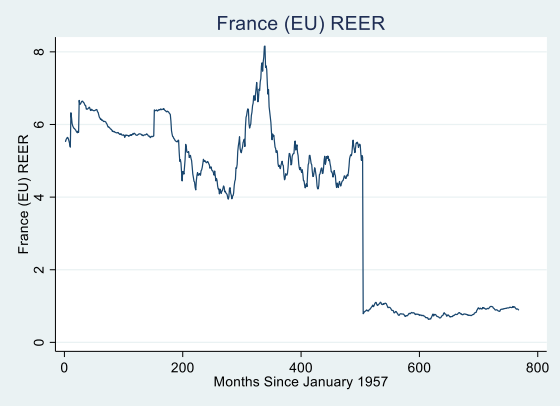

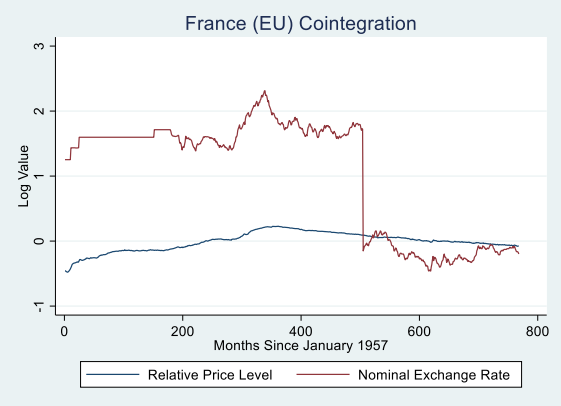

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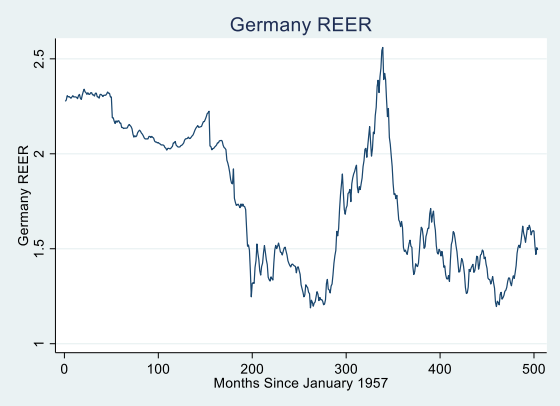

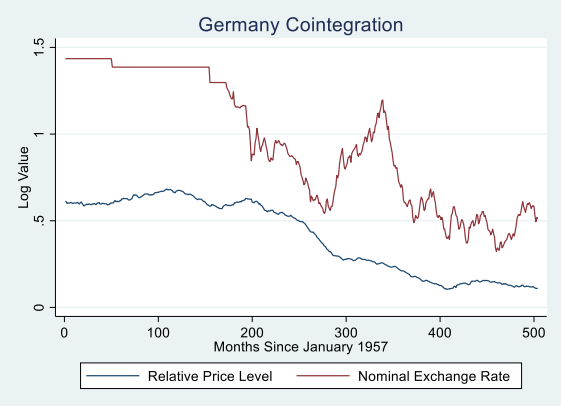

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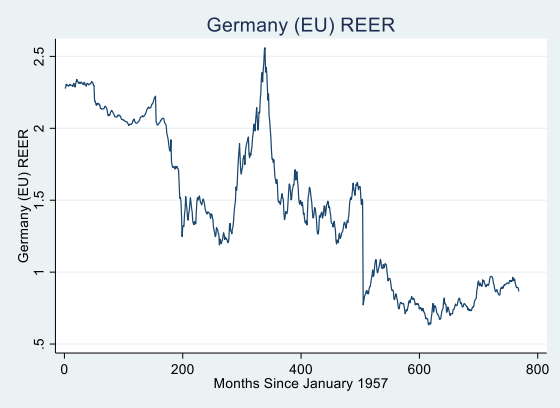
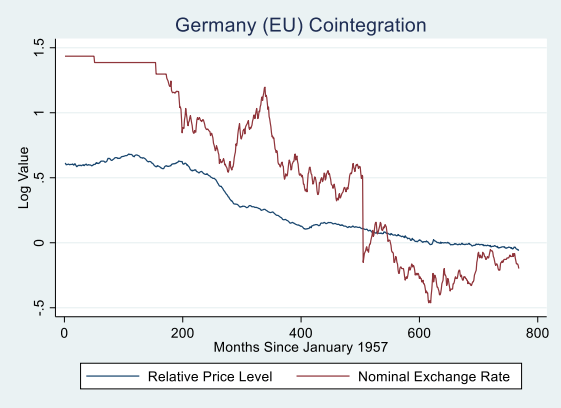
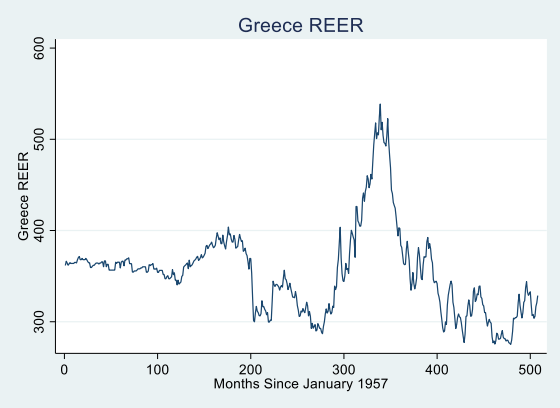
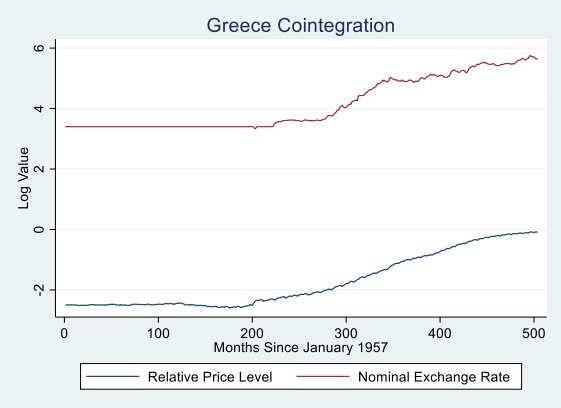




Greece





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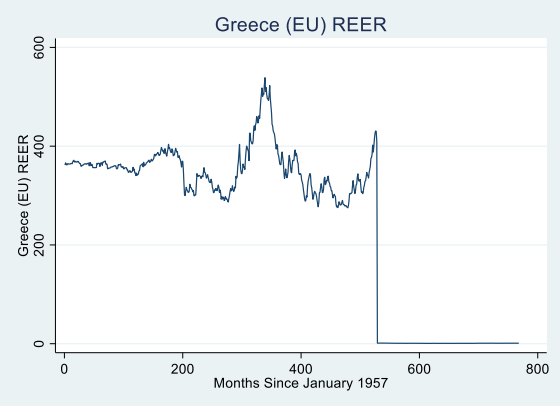
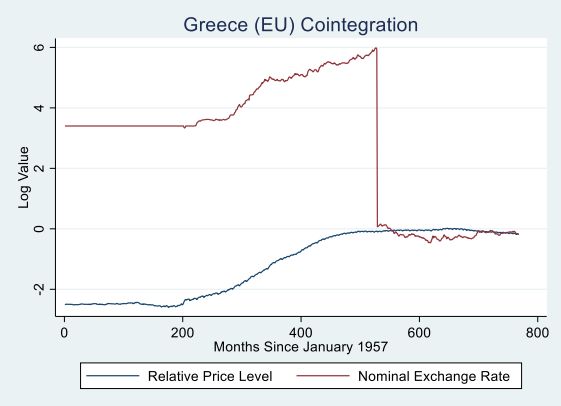
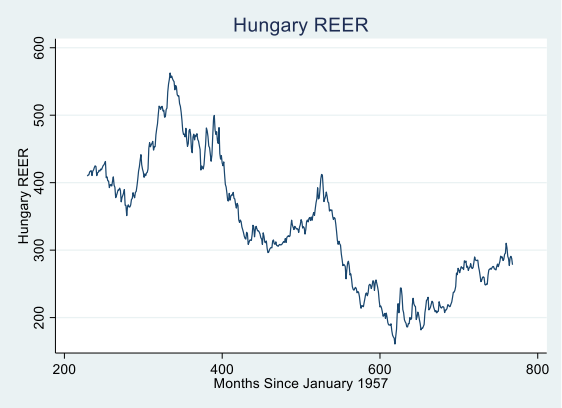
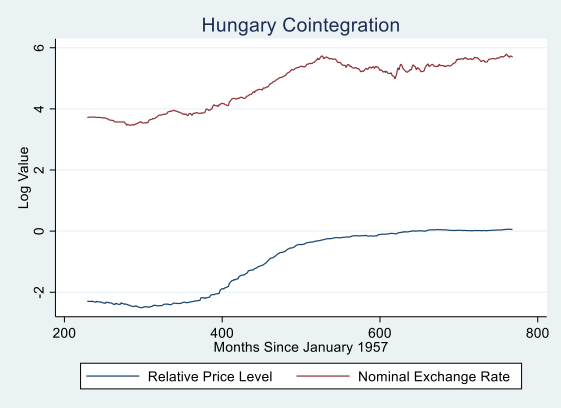




Hungary





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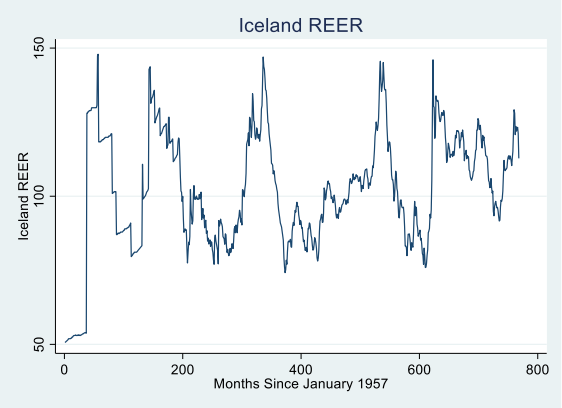
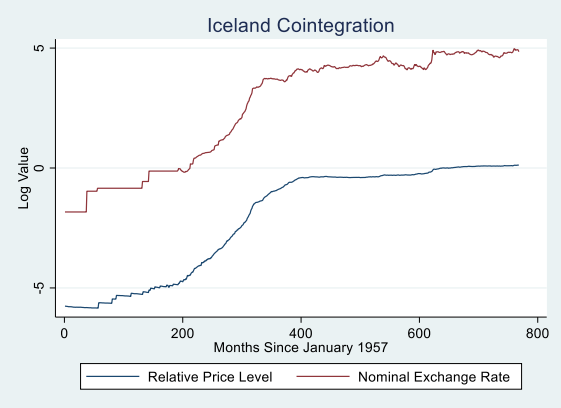
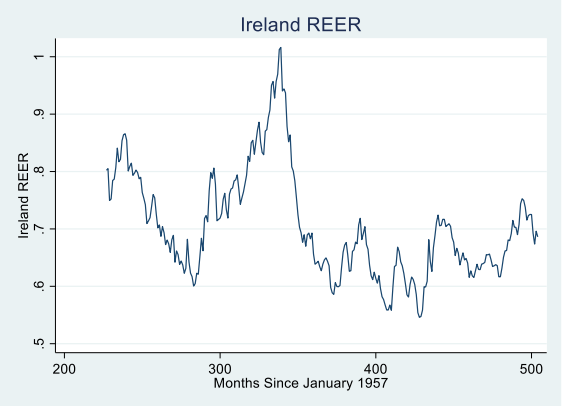
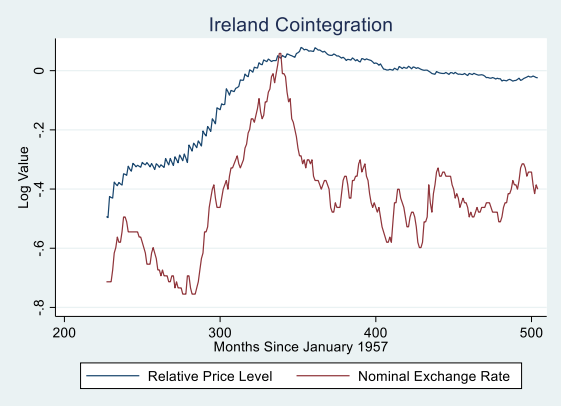




Ireland





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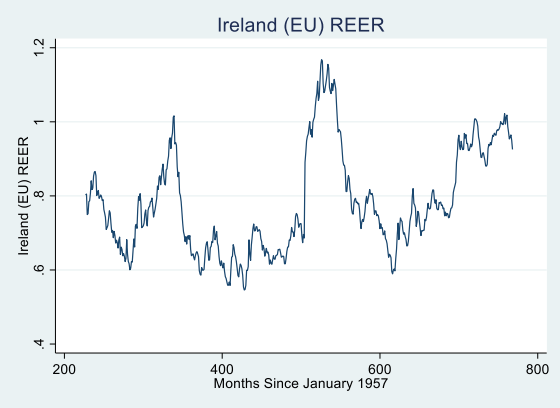

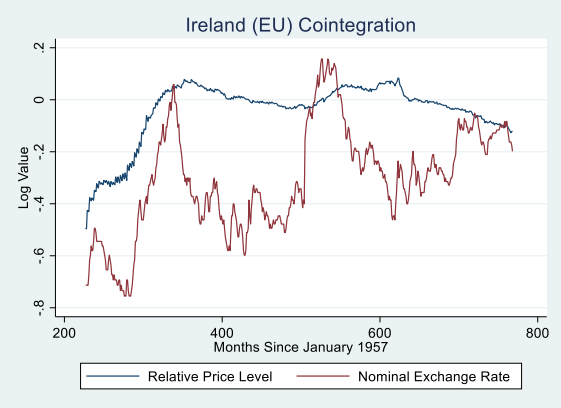

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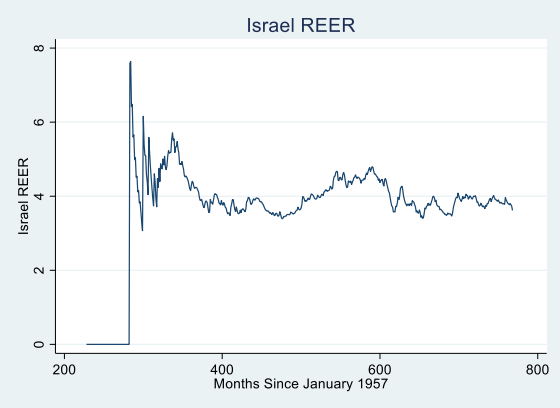
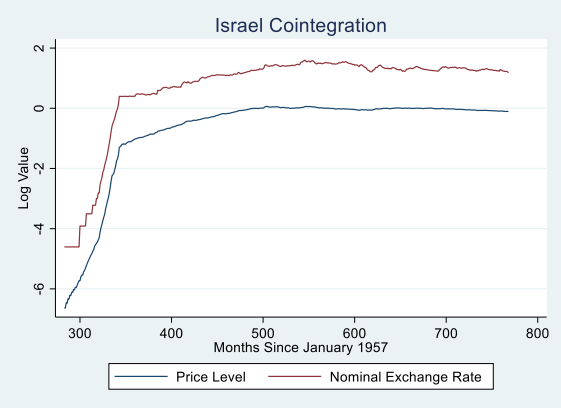
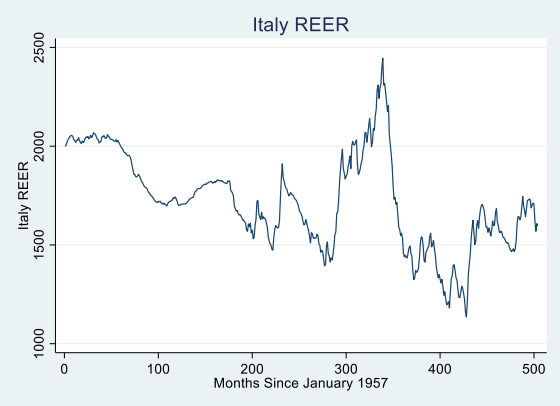
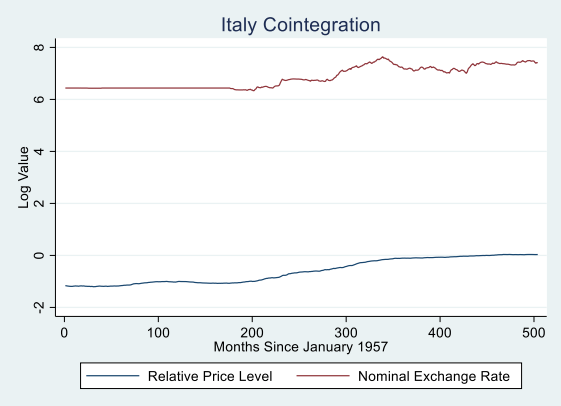


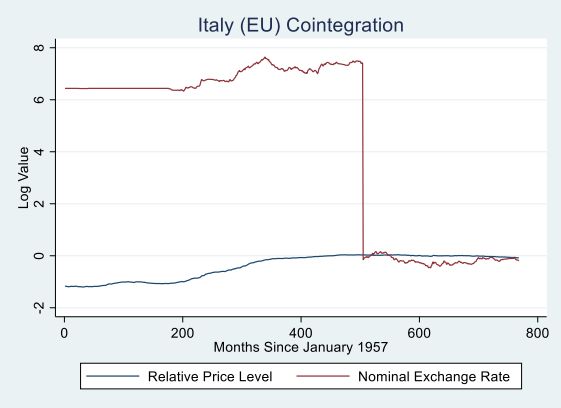


Italy

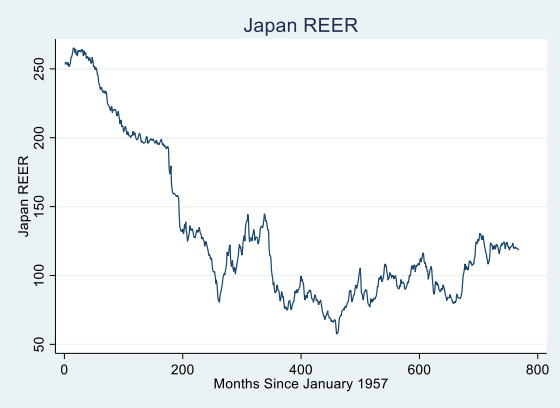


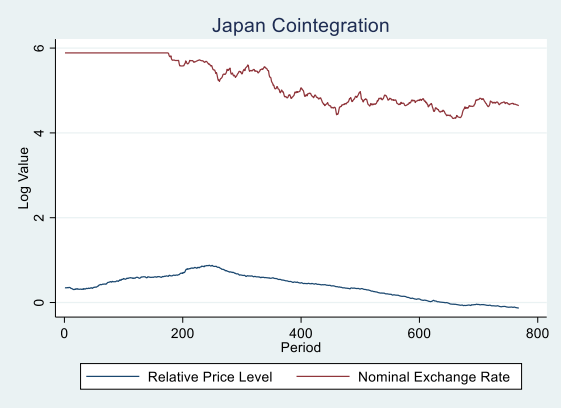


Italy (EU)



Japan





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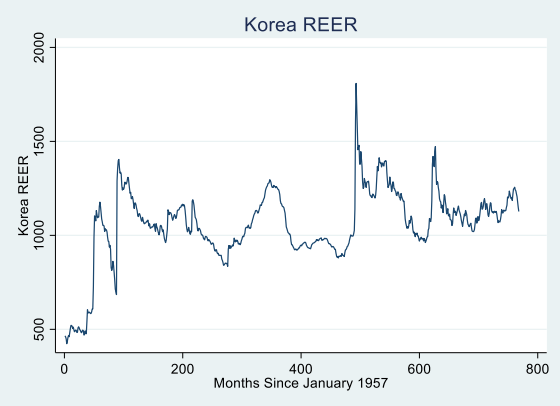
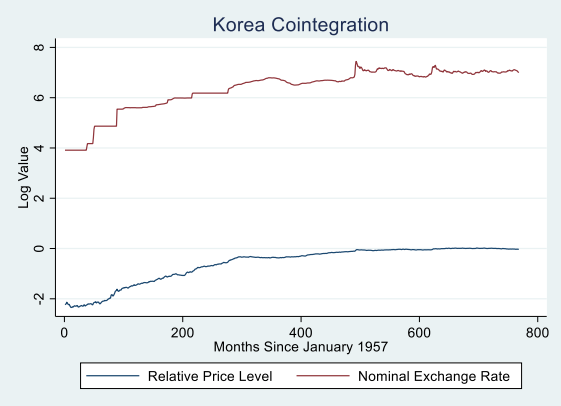
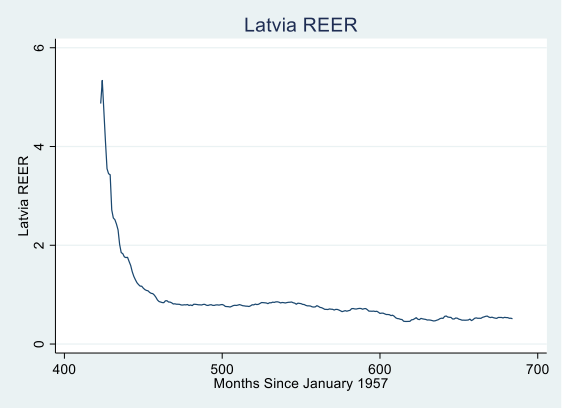
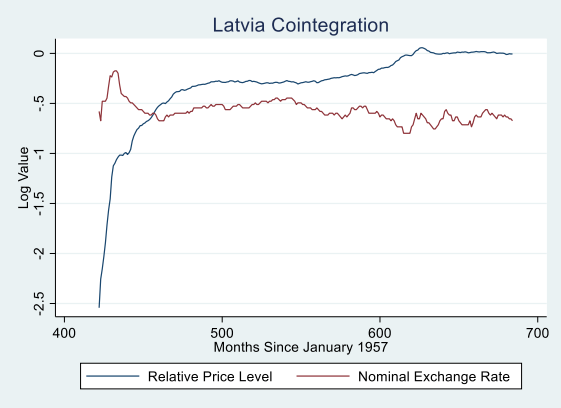


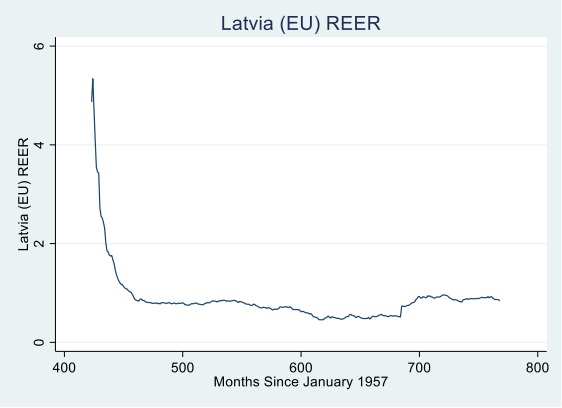


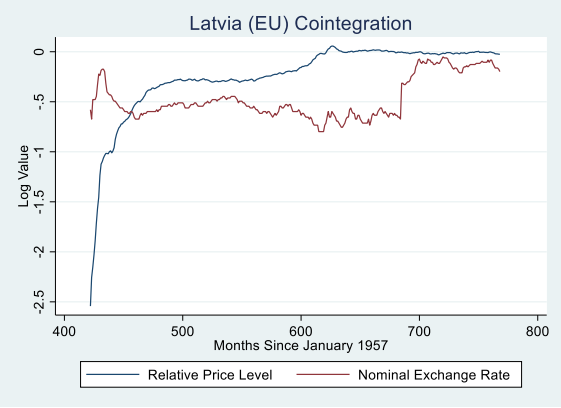
Latvia



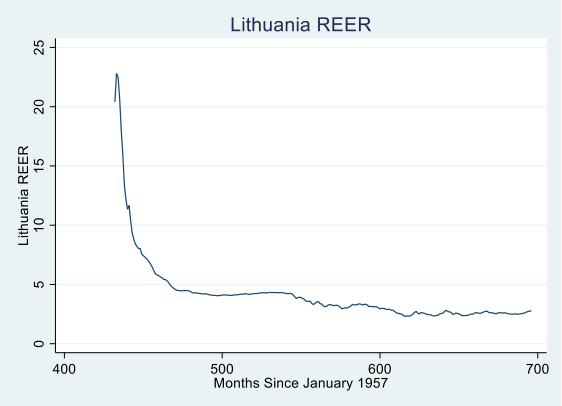


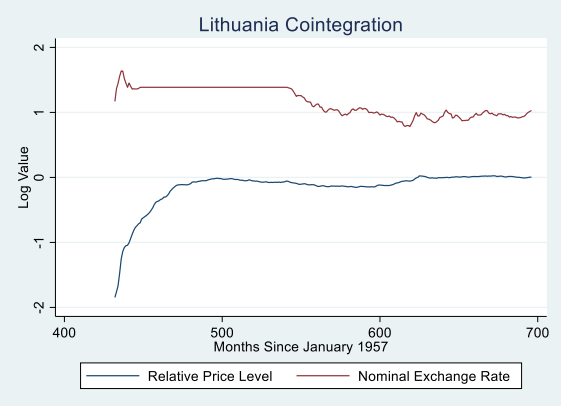
Latvia (EU)



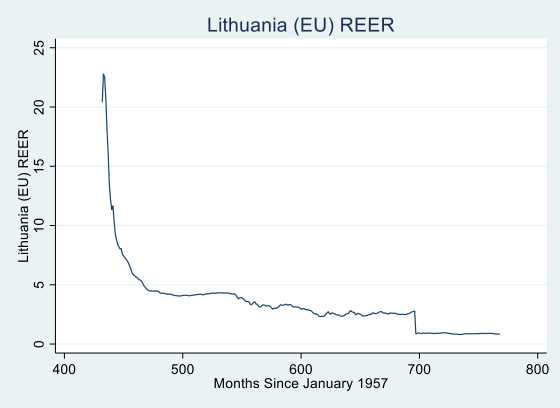


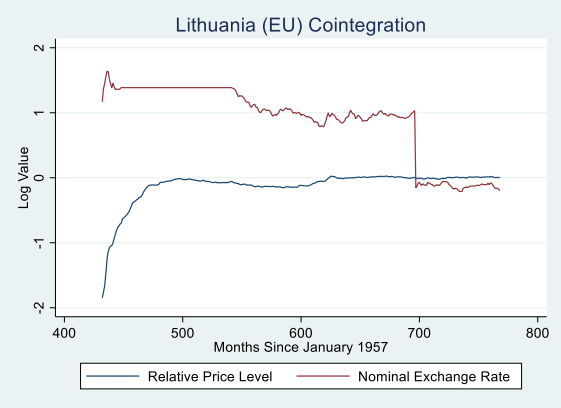
Lithuania



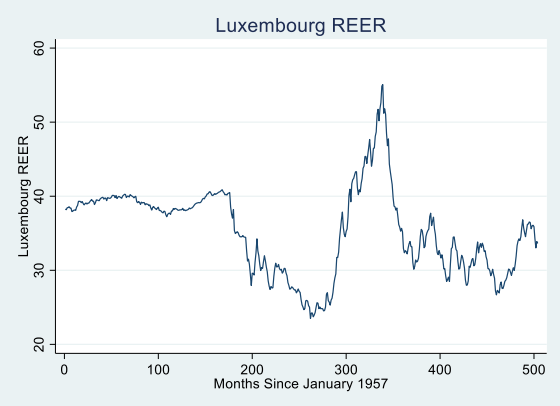


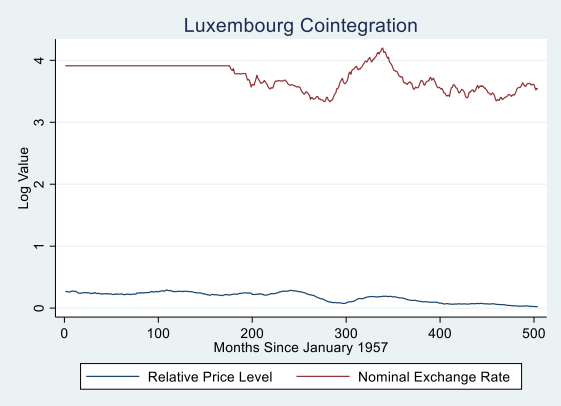
Lithuania (EU)



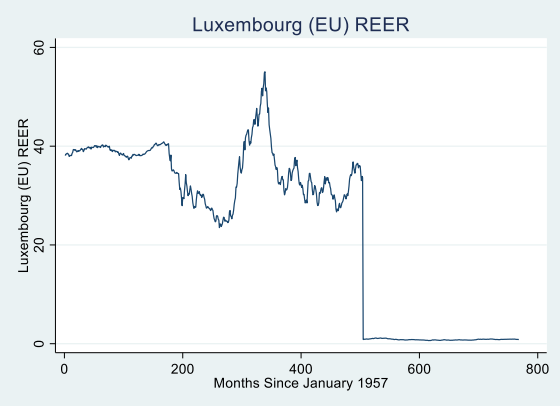


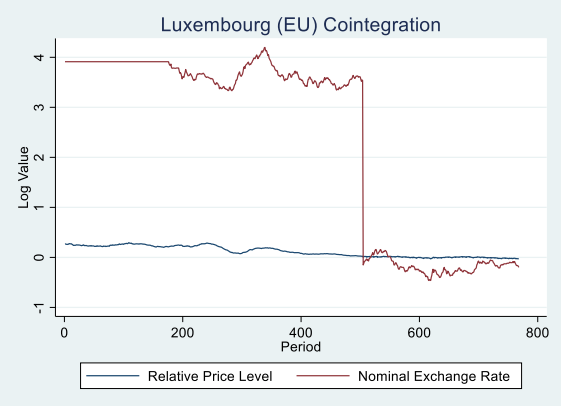
Luxembourg



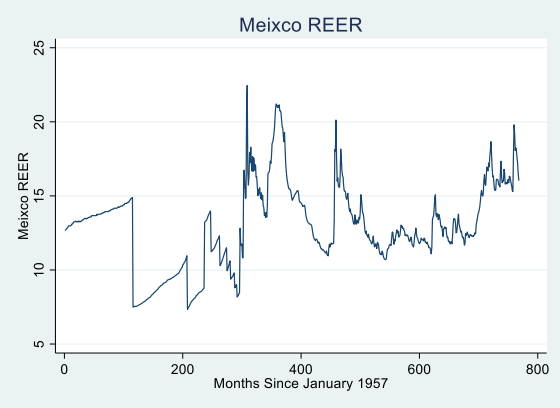


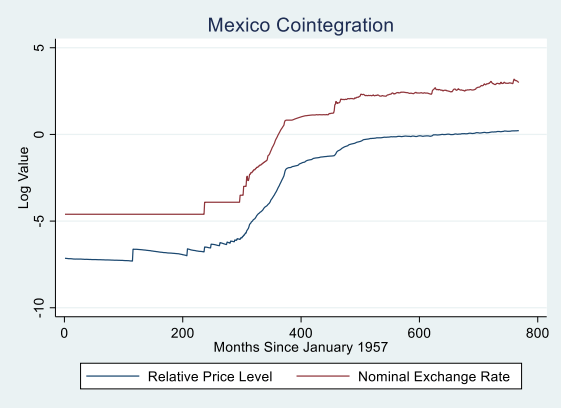
Luxembourg (EU)



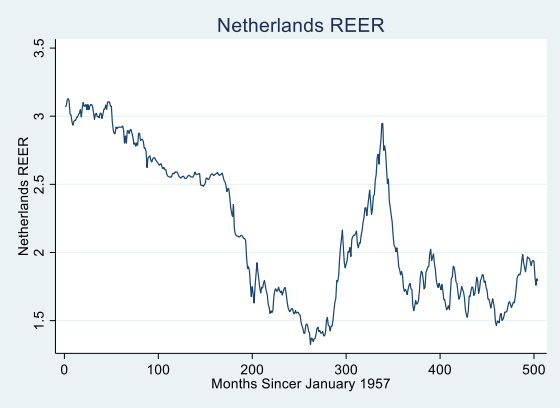


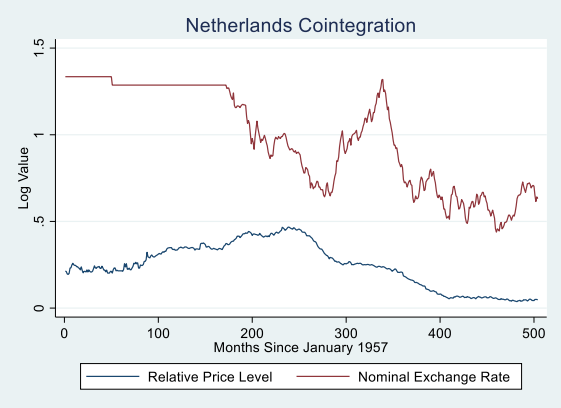
Mexico





Netherlands





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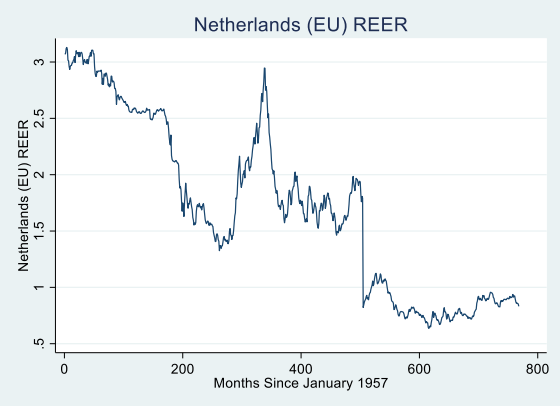
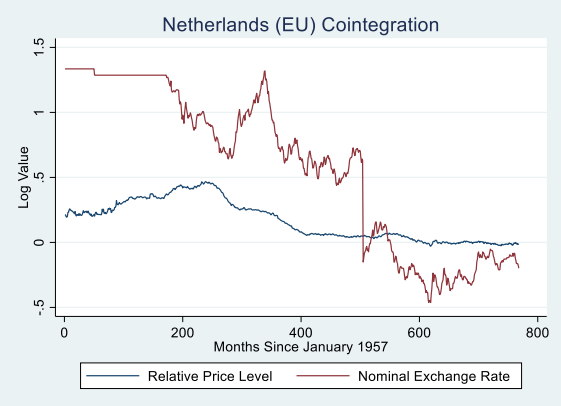
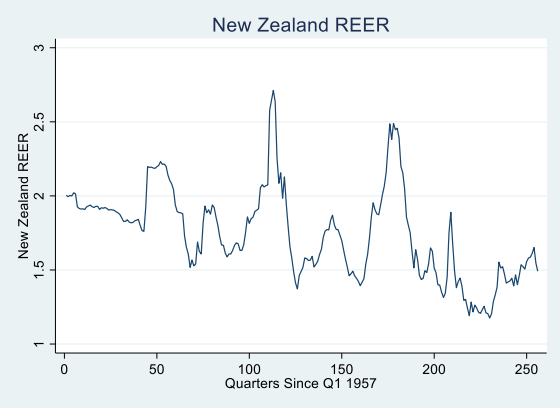
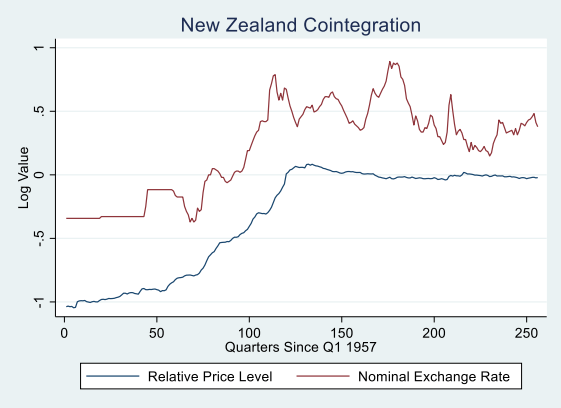


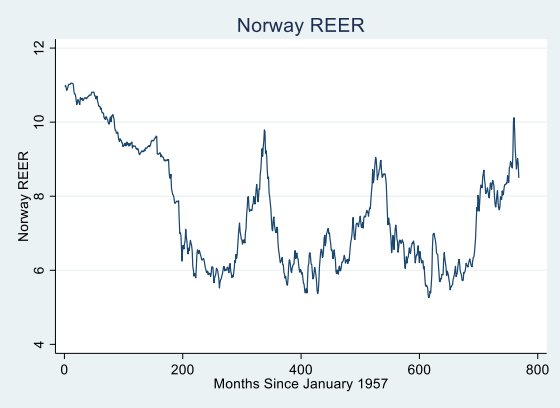


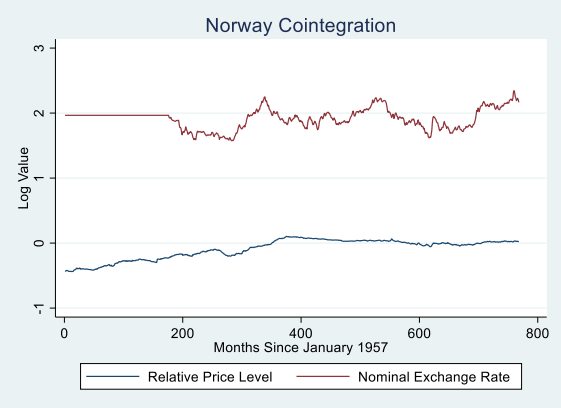
New Zealand



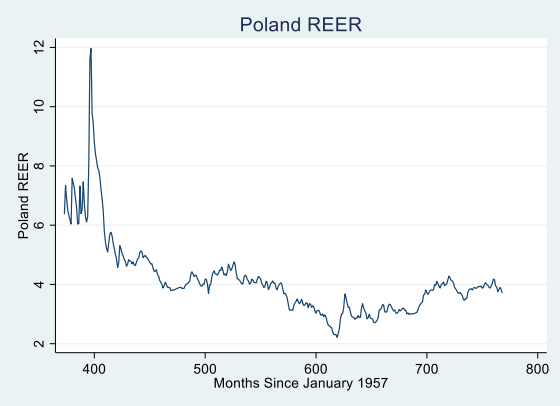


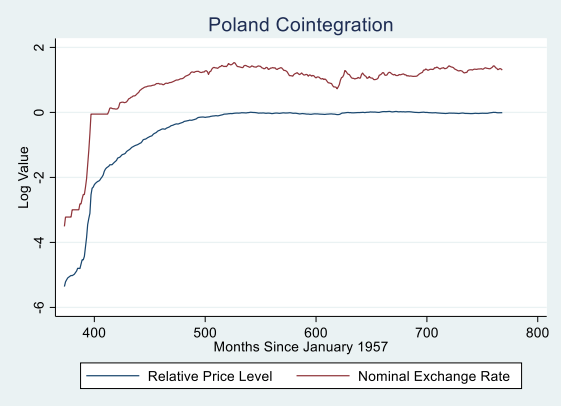
Norway



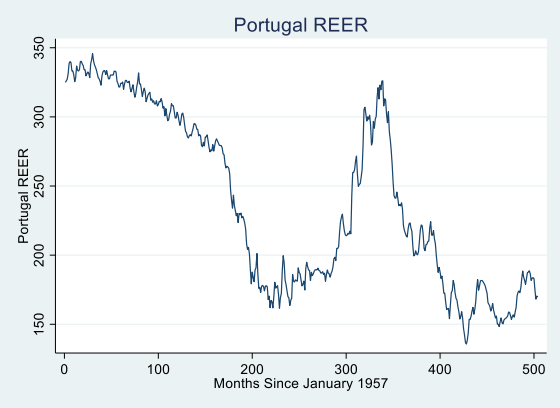


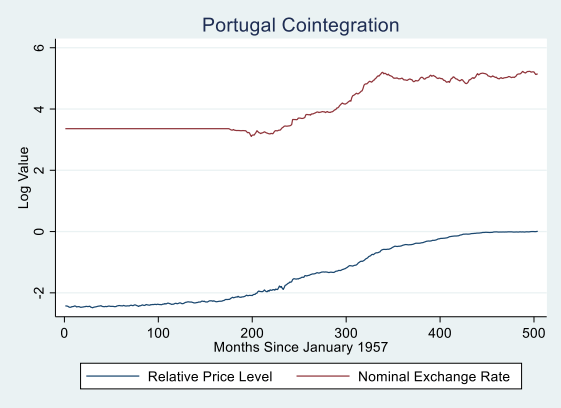
Poland



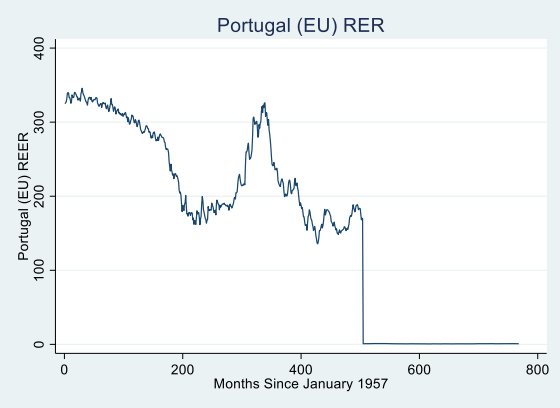


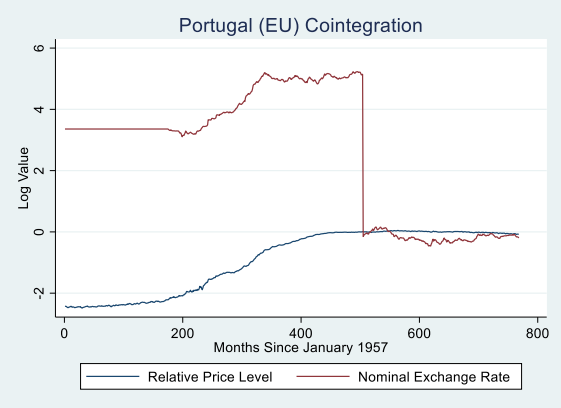
Portugal



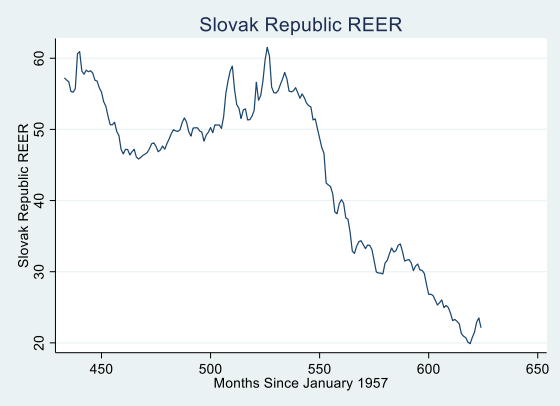


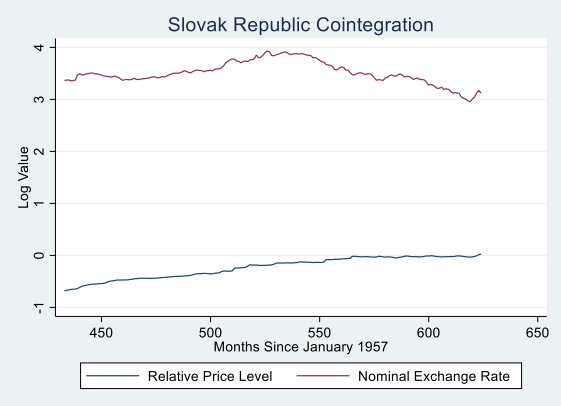
Portugal (EU)



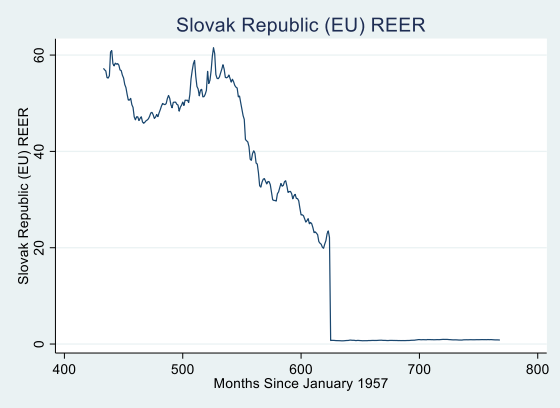


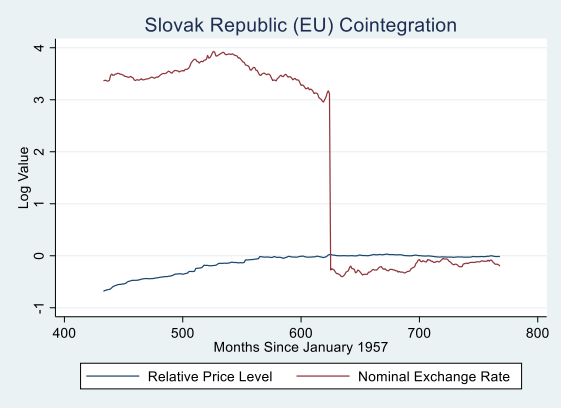
Slovak Republic



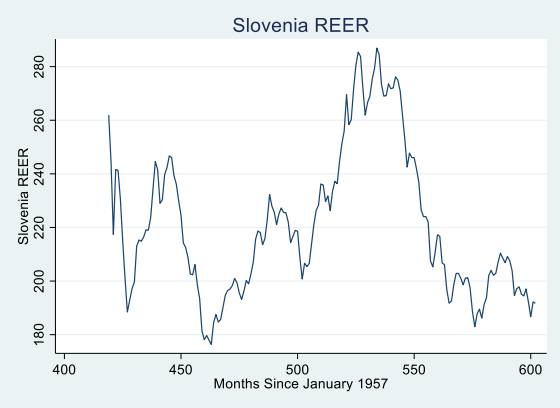


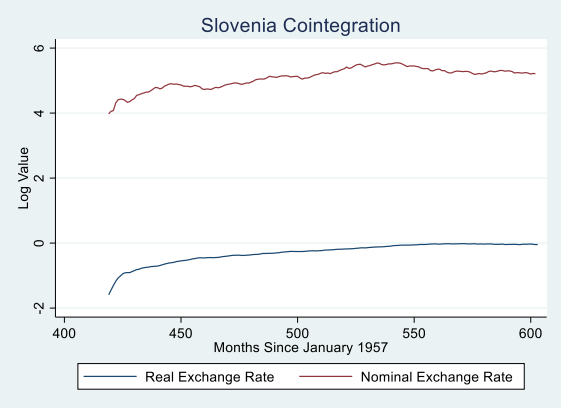
Slovak Republic (EU)





Slovenia





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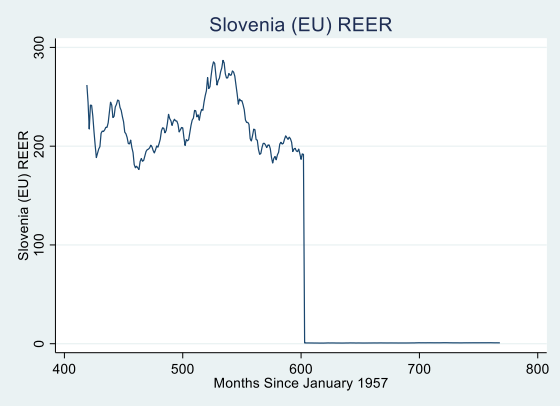
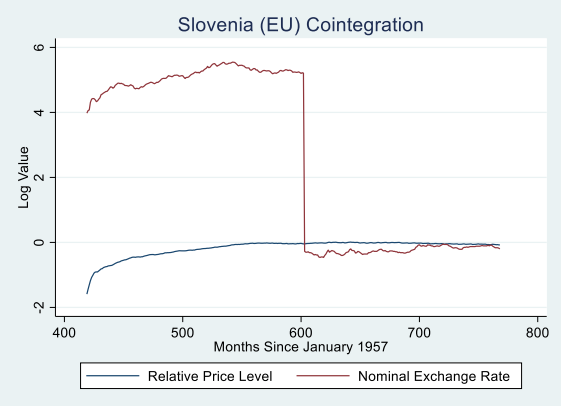
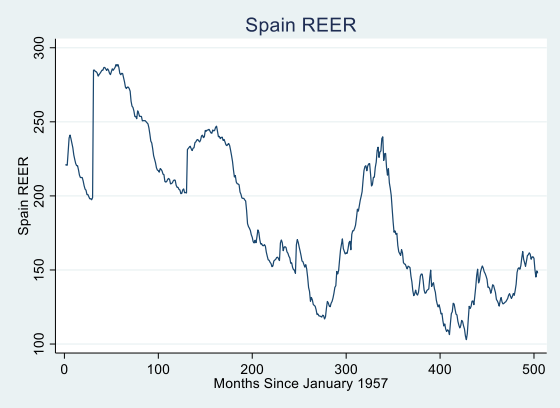
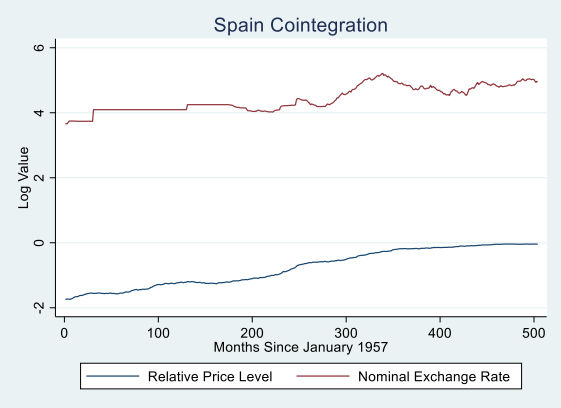


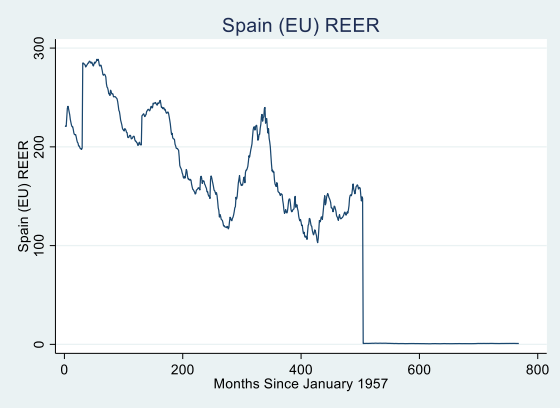


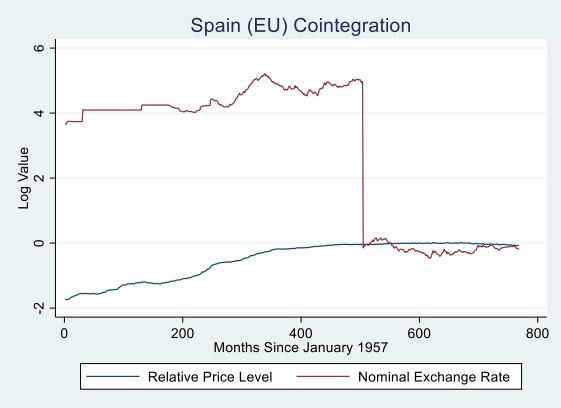
Spain



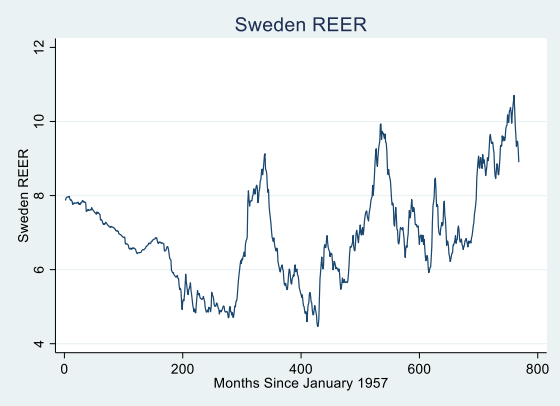


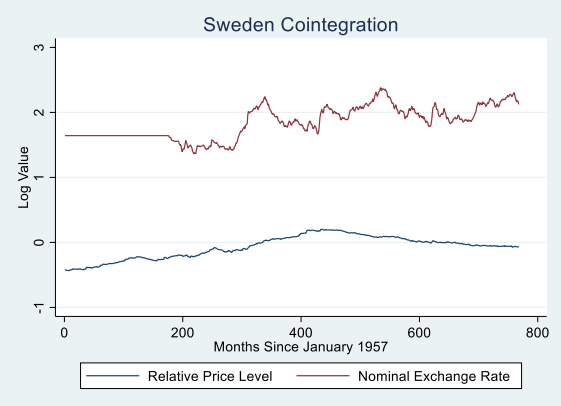
Spain (EU)



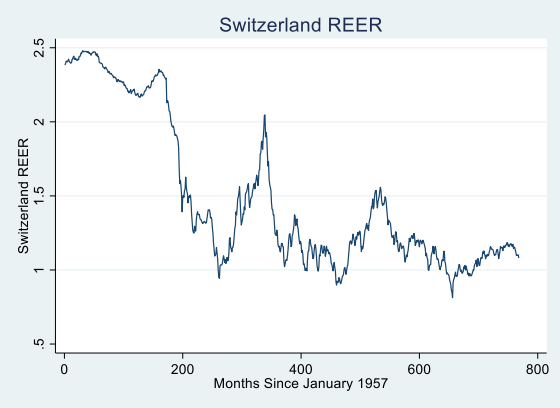


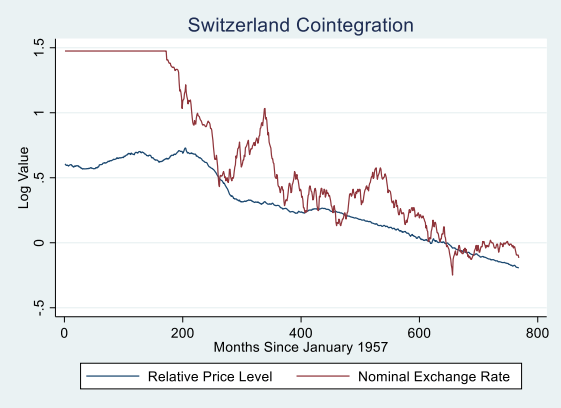
Sweden



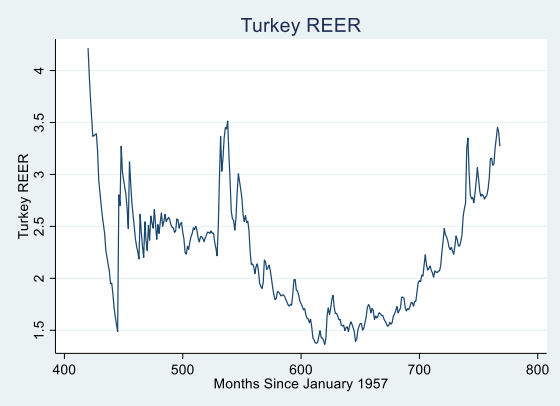


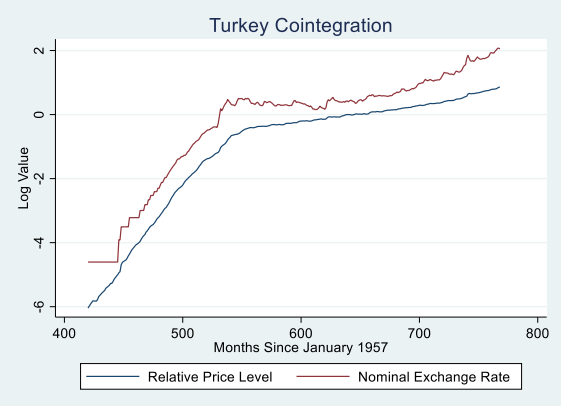
Switzerland





Turkey





UK