Analysis of the PPP and the UIP in Iceland Under Disparate Monetary Regimes

A Multivariate Cointegrated Modeling Approach

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30 ECTS thesis submitted in partial fulfillment of a
Magister Scientiarum degree in Business Finance

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School of Business
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Lovingly dedicated to my father, Sigurður Árnason
The world's best dad

Abstract

In the case of small open economies like Iceland, exchange rate stability is one of the key determinants of achieving the primary goals of monetary policy (price stability). Monetary policy in Iceland has faced obstacles in the past century due to high vulnerability to external shocks and weak policy frameworks. This thesis aims to investigate international transmission effects between countries through determination of exchange rate, interest rates, and prices, as assumed by the purchasing power parity (PPP) and the uncovered interest rate parity (UIP) relation during disparate monetary regimes in Iceland. The empirical study is based on the analysis conducted by Johansen & Juselius (1992) for the UK using the multivariate error correction model, where the short-run dynamics and the long-run relationships are estimated between economies. The model is five-dimensional and contains the consumer price index (CPI) and short-term interest rates in the economic areas and the exchange rate between them. This study focuses on the long-run equilibrium between Iceland and developed large economies; the Eurozone (EUR), the United Kingdom (UK) and the United States (USA). The PPP and UIP are shown to exist in some form prior to the financial crisis for the UK and the Eurozone, and for the US during capital controls. Furthermore, the results indicate that there is a relationship between the goods and financial market between the US during capital controls but next to none for the Eurozone or the UK.

Útdráttur

Í smáum opnum hagkerfum eins og Íslandi, er gengisstöðugleiki einn af megin áhrifaþáttum í því að stuðla að meginmarkmiði peningamálastefnu (verðstöðugleiki). Erfitt hefur verið að framfylgja peningamálastefnu á Íslandi síðastliðna öld vegna berskjöldunar gagnvart ytri áhrifum og veikrar stefnumörkunar í peningamálum. Í þessari ritgerð er kaupmáttarjafnvægi (PPP) og óvarið vaxtajafnvægi (UIP) metið fyrir Ísland gagnvart öðrum löndum fyrir ólík tímabil í peningamálastefnu hér á landi. Rannsóknin er byggð á greiningu sem var framkvæmd af Johansen & Juselius (1992) fyrir Bretland með því að nota margvítt frávikleiðréttingar líkan, þar sem skammtíma og langtíma sambönd eru metin milli hagkerfa. Líkanið er fimmvítt og notast við vísitölu neysluverðs (CPI) og skammtíma vexti innan efnahagssvæða ásamt genginu milli þeirra. Hér er einblínt á langtíma jafnvægi Íslands við stór þróuð hagkerfi; evrusvæðið (EUR), Bretland (UK) og Bandaríkin (US). Niðurstöður gefa til kynna að kaupmáttar- og óvarið vaxtajafnvægi sé til staðar að sumu leyti fyrir fjármálahrunið gagnvart evrusvæðinu og Bretlandi, og fyrir Bandaríkin yfir tímabil fjármagnshafta á Íslandi. Ennfremur gefa niðurstöðurnar til kynna að samband sé á vöru- og fjármagnsmarkaði milli Íslands og Bandaríkjanna á tíma fjármagnshafta, en nánast ekkert fyrir evrusvæðið og Bretland.

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Acknowledgments

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1. Introduction

The purchasing power parity (PPP) and the uncovered interest rate parity (UIP) are often used to explain linkages in the goods and financial markets between economic areas. These theories make the assumption that the price level and interest rates between two economic areas should adjust towards long-run equilibrium through the exchange rate between them. These equilibria are then used as assumption for other economic models. There are many empirical results that reject the existence of these hypotheses, this is considered to be due to disparate behavior of demand and supply in markets and multiple other factors (Krugman et al., 2012). There are many models that are used to test these theories. In this thesis the vector error correction model is used as it models both the long-run relationship and the short-run dynamics between variables. This allows for inference regarding long-run coefficients with some noise reduction from the short-run dynamics.

The aim of this thesis is to investigate the PPP and UIP during disparate monetary regimes in Iceland. Firstly, the period from 1994 to 2008 when Iceland joined the European Economic Area (EEA) until the financial crisis of 2008, a period characterized by a floating exchange rate with inflation targeting. And secondly, the period after the financial crisis after the imposition of capital controls in Iceland, 2009 to 2018. And finally the whole period, 1994 to 2018, is analyzed to include the affects of the financial crisis of 2008. The interaction between variables is examined for the long-run PPP and UIP relationships during these different monetary regimes using the VECM methodology.

The structure of this thesis is as follows. In Chapter 2, the mechanics the purchasing power parity and the uncovered interest rate parity are explained along with the policy trilemma for countries. In Chapter 3, results of previous studies of the PPP and UIP for the UK and Iceland are discussed and the methodology that has been used for these studies using the VECM. In Chapter 4, the econometric

methodology for the vector error correction model is explained along with the tests used in this thesis. Chapter 5 presents the data used in the study and discussion of the results. Chapter 6 concludes the thesis with summation of the results and future work.

2. Background

2.1. Interest Rates

Interest rates are among the fundamental variables in the economy as they, directly and indirectly, affect the decision-making mechanism of all economic players in some way. They also provide vital information on the state and financial health of individuals, firms and nations. Formally, interest rates is the rate charged by lenders in relation to the outstanding principal of a loan, quoted on annual basis in percentages. Take for example a one year zero-coupon bond

$$PV(1+i)^t = FV, \quad t = 1 \tag{2.1}$$

where PV is the principal of the loan, FV is the future value to be paid on at the maturity date which is the principal plus the interest rate charge, i. By rearranging this equation the discounted cash flow equation is derived,

$$PV = \frac{FV}{(1+i)^t} \tag{2.2}$$

and is used by investors to determine the feasibility of investments, also known as the time value of money (Mishkin & Eakins, 2015). Interest rates can furthermore be deconstructed by the Fisher equation, that states that nominal interest rates are a combination of real interest rates and expected rate of inflation denoted as

$$(1+i) = (1+r)(1+\pi^e) \tag{2.3}$$

where r is the real interest rate and π^e is the expected inflation rate. The implied expected rate of inflation can be derived in a fixed income market where a government (or public company) has issued both a nominal fixed-rate bond and an

inflation-linked bond of similar maturity (Choudry, 2006). Market interest rates are determined, inter alia, by a central bank's policy rate, central bank's open market operations, reserve requirements, supply of savings, demand for investments, foreign interest rates, government activities, risk, expected inflation and expected returns (Mishkin & Eakins, 2015).

2.2. Price (Inflation)

The price level of goods and services within an economic area is measured by calculating a weighted average for a basket of a hypothetical goods and services in an index that is called the consumer price index (CPI).

$$CPI_t = \sum_{i=1}^{n} w_{it} \cdot p_{it} \tag{2.4}$$

where w_i is the weight of each good or service and p_i is the price of that good or service at time t. In reality, however, the calculation of the CPI is carried out with multiple methods that will not be discussed here; see (Gudnason, 2004) for explanation of the methods used to calculate the Icelandic CPI. Note that not only does the price level of each item in the basket change throughout time, but also the weight and composition of the basket. Inflation is defined as the year-on-year increase in the CPI,

$$\pi = \frac{CPI_t}{CPI_{t-12}} - 1 \tag{2.5}$$

In recent decades many central banks have adopted the inflation targeting regime as the primary long-run goal of monetary policy as a nominal anchor. This goal to maintain price stability adheres well with other monetary policy goals in in the long-run such as, low unemployment, financial and currency stability, and economic growth. Inflation targeting is considered to make monetary policy more transparent and holds central banks accountable for their actions, thus making future price developments less uncertain. The main objective of inflation targeting is to keep inflation low and stable in order to maintain confidence of the monetary policy, and consequently the economy. This confidence is eventually reflected in increased investments and economic activity (Mishkin & Eakins, 2015).

The formal adoption of inflation targeting as a monetary policy goal was led by New Zealand in 1990, followed by other countries shortly after. The United Kingdom adopted the goal in 1992, the Eurozone in 1998 (Scheller, 2006), Iceland in 2001 (Central Bank of Iceland, 2001) and the United States in 2012 (Mishkin & Eakins, 2015). The central bank policy rate is believed to be the most effective instrument at the central bank's disposal to tie down inflation, Figure 2.1 shows the transmission mechanism of monetary policy as depicted by the Central Bank of Iceland (Danielsson et al., 2015).

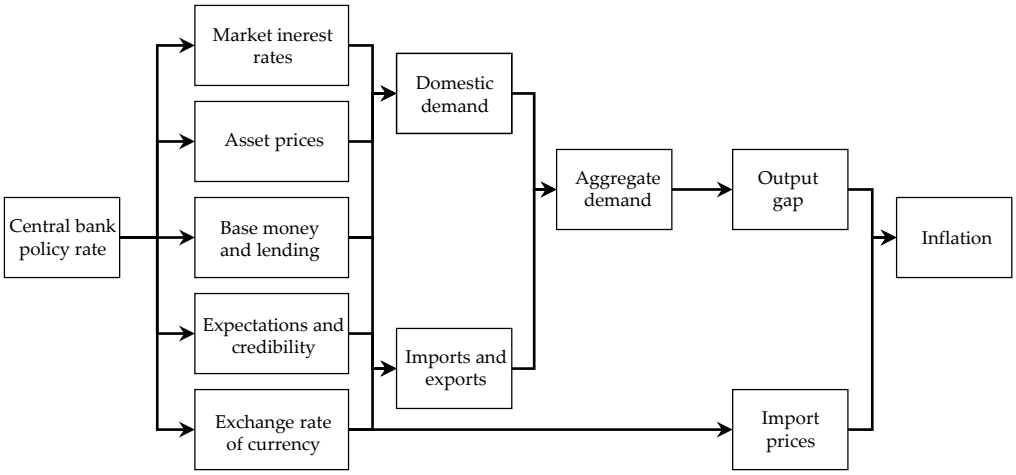

FIGURE 2.1: The Transmission Mechanism of Monetary Policy

2.3. Exchange Rates

The exchange rates of currencies is fundamental for international trade. The price of a currency is determined by its supply and demand in the foreign exchange market. If demand for the Icelandic krona (ISK) increases it appreciates, and depreciates if it decreases. So, for example if demand increases for Icelandic goods and services the ISK is likely to increase and vice versa. The exchange rate of a country's currency is thus the main determinant of its competitive advantage (Krugman et al., 2012). The price of a foreign currency, denominated in domestic currency, is given by the exchange rate

$$E_{d/f} = \frac{Domestic\ currency}{Foreign\ currency} \tag{2.6}$$

Exchange rates are determined by a myriad of factors, both within the economic area and international markets. The main variables used to evaluate future developments of exchange rates are the interest rate differential and expected price developments (inflation) between countries. The methods used for this evaluation are presented in Figure 2.2.

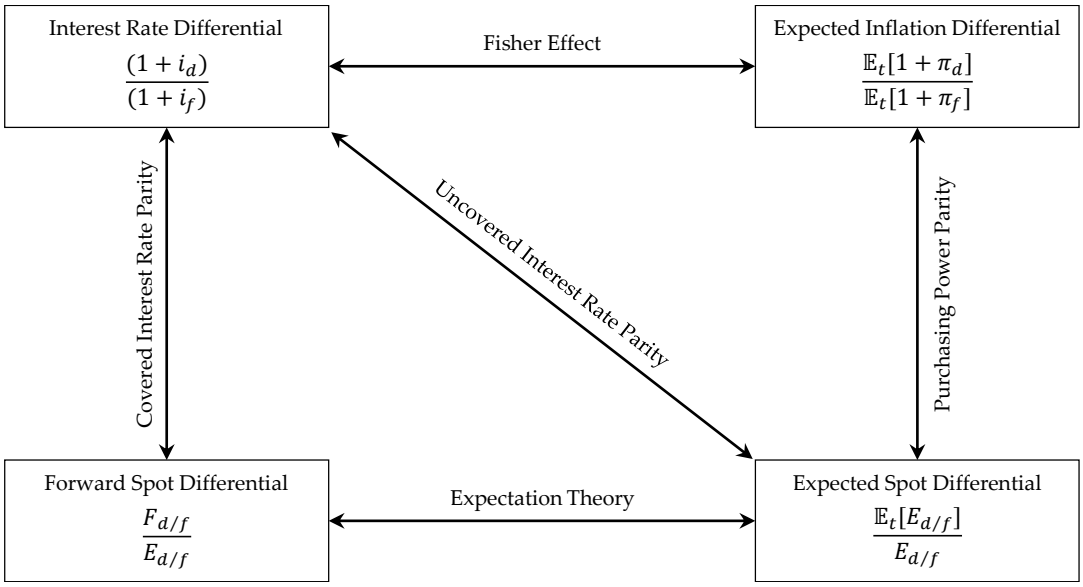

FIGURE 2.2: International Relations of Interest Rates, Exchange Rates and Inflation

In examining the exchange rate the forward spot differential would be interesting. Information regarding the forward exchange rate, $F_{d/f}$, for the Icelandic krona, however, is not readily available as it is traded as an over-the-counter (OTC) product. Thus, the covered interest rate parity (CIP) will not be investigated in this study.

2.4. Purchasing Power Parity

The theory of purchasing power parity (PPP) explains the exchange rate movements of currencies between two economic areas by changes in the price level of the economic areas. The purchasing power parity is presented in Equation 2.7

$$E_{d/f} = \frac{P_d}{P_f} \tag{2.7}$$

where P is the price level of the same basket of goods in the domestic market, d, and the foreign market, f (Krugman et al., 2012). This equation is referred to as the absolute purchasing power parity. By taking the logarithm the equation becomes,

$$e_{d/f} = p_d - p_f$$

where lower case letters are defined as the logarithm of the variable; note that here logarithm means the natural logarithm and is used interchangeably throughout this thesis. So if foreign price level increases more than the domestic, the domestic currency will appreciate ($p_f > p_d \rightarrow \downarrow e_{d/f}$).The relative purchasing power parity states that exchange rate movement in percentages over some period t are equal to the price level movement between the countries over the same period, given by

$$\frac{E_{d/f,t}}{E_{d/f,t-1}} = \frac{P_{d,t}/P_{d,t-1}}{P_{f,t}/P_{f,t-1}} \tag{2.8}$$

Now by taking the logarithm the equation becomes,

$$e_{d/f,t} - e_{d/f,t-1} = p_{d,t} - p_{d,t-1} - p_{f,t} + p_{f,t-1} \tag{2.9}$$

$$\Rightarrow \Delta e_{d/f,t} = \Delta p_{d,t} - \Delta p_{f,t}$$

So, if inflation in the foreign country is greater than the inflation in the domestic country the domestic currency appreciates ($\Delta p_{f,t} > \Delta p_{d,t} \rightarrow \downarrow \Delta e_{d/f,t}$). An estimate for the price level of the same basket of goods between economic areas is generally not published in practice. Thus, the absolute PPP is generally not considered a viable option. The relative PPP, however, can be utilized as it makes sense to compare percentage exchange rate changes to the inflation differential between the economic areas – even though the coverage and composition differ. The intrinsic behavior between these variables in the short-run differ a bit. Exchange rates are known to fluctuate and can jump in levels, while price level tends to be sticky and generally has a time trend so this is thought to be the long-run relationship (Krugman et al., 2012). This thesis analyzes the long-run relationship of the absolute version of the PPP.

2.5. Uncovered Interest Rate Parity

The uncovered interest rate parity is an equilibrium condition in the foreign exchange market, where the expected rate of return for currency deposits is offset by its exchange rate, ensured by arbitrage. The uncovered interest rate parity is given by,

$$\frac{(1+i_d)}{(1+i_f)} = \frac{\mathbb{E}_t[E_{d/f}]}{E_{d/f}} \tag{2.10}$$

by taking the logarithm this becomes,

$$i_d - i_f \approx \mathbb{E}_t[e_{d/f}] - e_{d/f} \tag{2.11}$$

so for an increase in the domestic country's interest rates and foreign interest rates are constant the domestic currency is expected to appreciate ($\uparrow i_d \rightarrow \downarrow \mathbb{E}[e_{d/f}]$) (Krugman et al., 2012). Although this parity clarifies the interaction between interest rates and exchange rates there are multiple variables that affect them individually; like risk premiums, fiscal and monetary policy uncertainty and more (Mishkin & Eakins, 2015). However in this study, further assumptions on this relationship are not considered.

2.6. The Policy Trilemma

In recent centuries the international monetary system has evolved greatly with the continuous integration between economies along with technological breakthroughs, political partnerships and treaties, and other major social and economic factors. When a country participates in the international monetary system it faces the policy trilemma, i.e. it can only pursue two of the three following policies at the same time:

- Exchange rate stability
- Monetary independence towards domestic goals
- Free movement of capital across borders

There are many aspects a country has to consider when choosing which policy should

be pursued. Examples of the options for countries can be observed in Figure 2.3, where each side of the triangle represent the monetary policy a country can pursue. In 1787 the United States chose option 2 within its economic area and now maintains option 1 in their international relations. In 1999 the euro was adopted by European countries that were part of the European Monetary Union, option 2, and like the US they pursue option 1 in their international monetary system. China maintains option 3 by restricting capital flows across its borders (Krugman et al., 2012; Mishkin & Eakins, 2015).

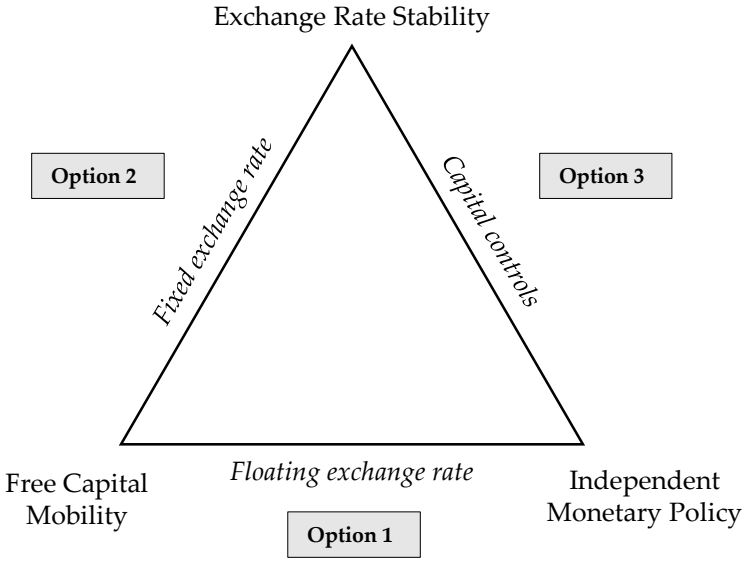

FIGURE 2.3: The Policy Trilemma

In 1993 the foreign exchange market was established in Iceland and in 1994 it became a founding member of the EEA, which allowed the freedom of movement of capital, labor, goods and services within the EEA. During this period until 2001 the exchange rate was the nominal anchor (Gudmundsson et al., 2000). In March 2001 the Central Bank of Iceland adopted inflation targeting and the Icelandic krona (ISK) was set to float (Central Bank of Iceland, 2001). Following the financial crisis of 2008, the floating exchange rate was abolished with the imposition of capital controls in Iceland to protect the economy and maintain exchange rate stability. The country experienced much turmoil some years following the crisis, but in March 2017 almost all capital controls were lifted. The remainder of the capital controls were reserve requirement in the fixed income market for foreign investors, that were lifted in March 2019.

In summary, from 1990s to March 2001 the exchange rate was the nominal anchor for Iceland and had free movement of capital and more within the EEA. From March 2001 to 2008 inflation targeting was pursued with a floating exchange rate. And from 2008 until 2017 a managed float was maintained alongside the capital controls with inflation targeting as the nominal anchor. As of today, Iceland has gradually moved from option 3 to option 1 into what can be considered a managed float, as the central bank still intervenes in the foreign exchange market to mitigate short-term exchange rate volatility and prevent spirals from developing (Central Bank of Iceland, 2018).

3. Literature Review

The purchasing power parity and uncovered interest rate parity have been studied greatly in the past century, but empirical results have not given strong evidence for the existence of these parities (Krugman et al., 2012). In a paper presented by Johansen (1988) the methodology to analyze the short-run dynamics and the long-run relationship between variables with more than one cointegrating relationship was introduced, an extension to the Engle and Granger (1987) method for analyzing two vectors with one cointegrating relationship. This methodology has been widely used for econometric analysis since its conception. The main purpose of cointegrating analysis is to combat the misleading attributes of spurious regressions.

In Johansen & Juselius (1992) the purchasing power parity and the uncovered interest rate parity was investigated for the UK by examining a five dimensional vector error correction model. They used quarterly data from 1971Q1 to 1987Q2. With the variables, p_1 as the UK wholesale price index, p_2 as the trade-weighted wholesale price index, e_{12} as the UK effective exchange rate, i_1 as three-month treasury bill rate in the UK and i_2 as the three month Eurodollar interest rate. These variables, expressed in natural logarithms, were presented as $(p_1, p_2, e_{12}, i_1, i_2)$. They also included the world oil prices as an exogenous variable to take into account the oil crises in 1973 and 1979. The results from this study were quite amazing as the estimates were close to the hypothetical PPP $(a_i, -a_i, -a_i)$ relation. The uncovered interest rate parity, however, was not present in these results.

In a paper presented by Petursson & Tomasson (1994), they examined the PPP and the UIP for Iceland for two periods when the economy and the financial system was rather underdeveloped. For the two models they used similar data as Johansen and Granter did at a quarterly basis. The data used for this study was the consumer price index, multiple interest rates and nominal exchange rates; the data was

quite comprehensive and will not be detailed here, interested readers are directed to the appendix of that paper. The first model is estimated for the period 1979Q1 to 1991Q3 and the second one from 1984Q1 to 1991Q3. Their first model indicated for almost all equations some type of PPP relation with correct signs but not hypothetical values. They found that with the second model there was existence of a PPP relation, due to correct signs of the parameters but the estimates did not match the hypothetical ones. Along with these results there was an indication that foreign interest rates are weakly exogenous. They also point out that one should be careful when making alterations to the basic assumptions of the model due to parameter sensitivity, as that can change the results significantly.

In a more recent study by Birgisson (2009) the PPP and the UIP are examined in Iceland for the period January 1990 to June 2008 on a monthly basis. The data used in that study was the consumer price index, three month interbank rates and exchange rates. He analyzed these relationships, like this thesis, between Iceland and the Eurozone, the UK and the US. The results indicated that there was some type of PPP relation (correct signs but incorrect values) with the Eurozone but not for the other countries and no obvious relation for the UIP for any of the countries.

4. Econometric Methodology

4.1. Stationarity and integration

The stationarity of a data generating process (DGP) is the foundation of time series analysis. A process is strongly stationary if all finite-dimensional distributions are time invariant. A weaker version of stationarity is often assumed, known as covariance stationary process. A process is weakly stationary when its first two moments are time invariant, Equations 4.1 and 4.2, and its autocovariance function, Equation 4.3, only depends on the time interval h (Tsay, 2010; Madsen, 2008).

$$\mathbb{E}[Y_t] = \mu \tag{4.1}$$

$$\mathrm{Var}(Y_t) = \sigma^2 \tag{4.2}$$

$$\mathrm{Cov}(Y_t, Y_{t-h}) = \gamma_h = f(h) \tag{4.3}$$

Series that exhibit non-stationary characteristics can be a difference stationary process, commonly known as an integrated process. The order of integration, d, can be determined by conducting unit root tests. The test used in this thesis is the Augmented Dickey Fuller (ADF) test,

$$\Delta Y_t = \alpha + \beta t + \gamma X_{t-1} + \sum_{i=1}^{k} \delta_i \Delta Y_{t-i} + \varepsilon_t \tag{4.4}$$

where $\Delta Y_t = Y_t - Y_{t-1}$, α is a constant and β is a time trend coefficient. Here, γ is defined as $\gamma = (1 - \rho)$ and the following hypothesis is tested $H_0 : \gamma = 0$ vs. $H_a : \gamma < 0$. Lagged differenced terms ΔY_{t-i} are added until there is no presence of a serial correlation. The test can be conducted for (i) no constant and no trend, (ii) constant or (iii) constant and trend; critical values for the test can be seen in Table A.1.

4.2. Cointegration

Non-stationary processes are often encountered, e.g., due to long-term trends, periodic trends or other time-varying behavior. In multivariate time series analysis the regression of two or more non-stationary series that are not related in any way can produce results that are misleading. This type of regression is called a spurious regression. A good explanation regarding this topic was presented by Hendry (1980), where the relationship between the amount of money (M3) and cumulative rainfall in the UK is examined and a spurious regression is analyzed. As mentioned, non-stationary processes might be difference stationary, but by differencing the information of long-run relationship for variables is lost. However, if series are integrated processes of the same order d and have a linear relationship they are said to be cointegrated. If series are cointegrated, the short-run dynamics along with the long-run relationship between variables can be modeled jointly.

The model applied to analyze cointegrated series is the vector error correction model (VECM). To explain the VECM methodology the vector autoregressive (VAR) model is introduced. Consider the VAR(p) model for a k-dimensional stochastic processes $\{\boldsymbol{Y}_t, t = 0, \ldots, T\}$ that contains a time trend, given by the following equation

$$\boldsymbol{Y}_t = \boldsymbol{\mu}_0 + \boldsymbol{\mu}_1 t + \sum_{i=1}^{p} \boldsymbol{\Phi}_i \boldsymbol{Y}_{t-1} + \boldsymbol{\varepsilon}_t \tag{4.5}$$

where $\boldsymbol{\mu}_0$ and $\boldsymbol{\mu}_1$ are k-dimensional constant vectors, $\boldsymbol{\varepsilon}_t$ is Gaussian white noise i.e. $\boldsymbol{\varepsilon}_t \sim iid\ N(0, \sigma_\varepsilon^2)$ and $\boldsymbol{\Phi}_i$ is a $k \times k$ parameter matrix. The VECM for the VAR(p) process is then

$$\Delta \boldsymbol{Y}_t = \boldsymbol{\mu}_t + \boldsymbol{\Pi} \boldsymbol{Y}_{t-1} + \sum_{i=1}^{p-1} \boldsymbol{\Phi}_i^* \Delta \boldsymbol{Y}_{t-i} + \boldsymbol{\varepsilon}_t \tag{4.6}$$

where $\Delta \boldsymbol{Y}_t$ is the first difference of $\boldsymbol{Y}_t$. The coefficient matrix $\boldsymbol{\Pi}$ contains information on the long-run relationship among variables in $\boldsymbol{Y}_t$ and Rank($\boldsymbol{\Pi}$) reflects the number of cointegrating relations (r) among variables in $\boldsymbol{Y}_t$. If the variables are cointegrated they must obey an equilibrium relationship in the long-run. If there exists a cointegrated relationship then $\boldsymbol{\Pi}$ can be written as

$$\boldsymbol{\Pi} = \boldsymbol{\alpha} \boldsymbol{\beta}' \tag{4.7}$$

where $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$ matrix are $(k \times r)$ matrices. The coefficients in the $\boldsymbol{\alpha}$ matrix measure the speed of adjustment towards the long-run equilibrium (error correction vectors), and coefficients in the $\boldsymbol{\beta}$ are the long-run estimators of the variables (cointegrating vectors). The $\boldsymbol{\Phi}_i^*$ matrix contains information on the short-run dynamics in the cointegrated system (Tsay, 2010).

The Johansen test (Johansen, 1988) is used to determine the number of cointegrating relationships. The test examines the likelihood ratio for testing the rank of $\boldsymbol{\Pi}$. The test examines two statistics, the maximum eigenvalue statistics

$$\lambda_{max}(m) = -T \ln(1 - \hat{\lambda}_{m+1}) \tag{4.8}$$

where the hypothesis test is $H_0 : r = m$ against the alternative $H_a : r = m + 1$, and the trace statistics

$$\lambda_{trace}(m) = -T \sum_{i=m+1}^{k} \ln(1 - \hat{\lambda}_i) \tag{4.9}$$

where the hypothesis test is $H_0 : r = m$ against the alternative $H_a : r > m$. There are three cases of interest from the outcome of the test, they are:

1. Rank($\boldsymbol{\Pi}$) = 0. This implies that there exist no cointegrated relationships.
2. Rank($\boldsymbol{\Pi}$) = k. This implies the system contains no unit roots, so the VECM is not an appropriate model for the series.
3. Rank($\boldsymbol{\Pi}$) = $m < k$. Here there exist cointegrated relationships of order m.

The critical values for this test do not follow a standard distribution and have to be determined via simulation (Tsay, 2010).

5. Results

5.1. Data

The data sample was collated from January 1994 to December 2018, with monthly frequency. Monthly data was chosen instead of quarterly or yearly as it provides more observations ($T = 300$) and was thought to suffice in capturing short-term impact from variables. The euro was introduced in January 1999, replacing the European Currency Unit (ECU), so prior to the euro the ECU is used. The data was collected from the OECD, FRED and CBI in March 2019 (OECD, 2019b,a; FRED, 2019a,b; CBI, 2019). Description and sources for all variables is listed in Table 5.1.

Table 5.1: Summary of Variables

Variable	Description	Source
CPI_{ISK}	Monthly consumer price index	OECD[a]
CPI_{EUR}		OECD
CPI_{GBP}		OECD
CPI_{USD}		OECD
i_{ISK}	Short-term interest rates are monthly average	OECD
i_{EUR}	three-month money market rates	OECD
i_{GBP}		OECD
i_{USD}		OECD
E_{EUR}	Monthly average foreign exchange rate	FRED[b], CBI[c]
E_{GBP}	denominated in ISK	CBI
E_{USD}		CBI

[a] Organisation for Economic Co-operation and Development (OECD)

[b] Federal Reserve Economic Data (FRED)

[c] Central Bank of Iceland (CBI)

To analyze the long-run relationship between these variables during different monetary regimes the data is divided into three periods. Firstly, the period before the financial crisis, from January 1994 when Iceland joined the EEA that enabled free movement of capital, labor, goods and services until March 2008, roughly 6 months prior to the financial crisis in Iceland ($T = 171$). Secondly, the period following the financial crisis, one year after the capital controls were imposed, December 2009 until December 2018 ($T = 121$). And thirdly, the whole period from January 1994 to December 2018 ($T = 300$), that includes variables during the financial crisis. As observed in Figure 5.1 that shows the CPI (1994=100) for the countries to be examined, the financial crisis of 2008 impacted the Icelandic CPI significantly more than the other countries.

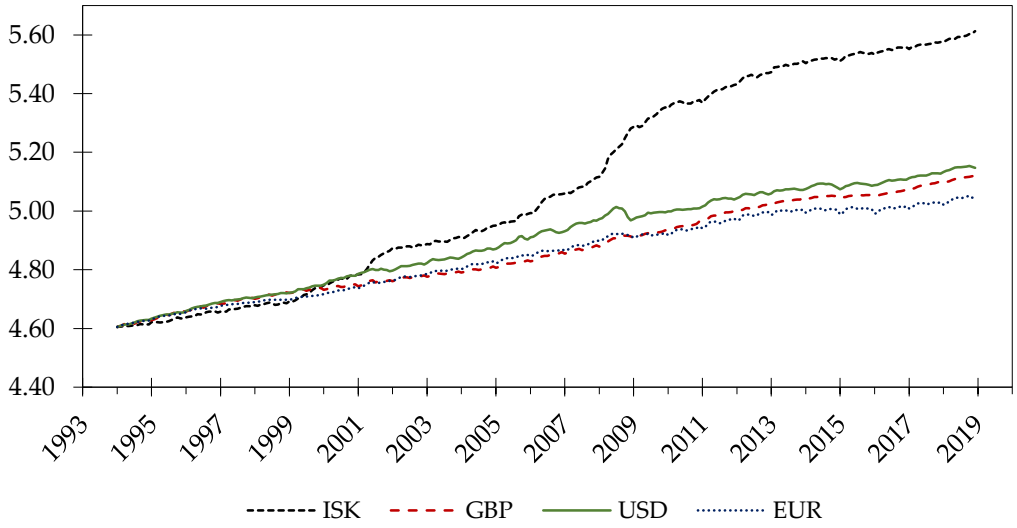

FIGURE 5.1: Consumer Price Index (logarithm)

The three noticeable sharp increases in the Icelandic CPI in 2001, 2006 and 2008 are all related to jumps in the exchange rates; see Figure 5.3. These events can somewhat be explained by the change of nominal anchor in monetary policy in 2001, the Geyser crisis in 2006 and lastly the financial crisis in 2008.

In Figure 5.2 the monthly average three-month money market rates for the four countries is presented. The Icelandic short-term rates diverge from the comparison rates around the time the Euro is introduced, and has been the highest since.

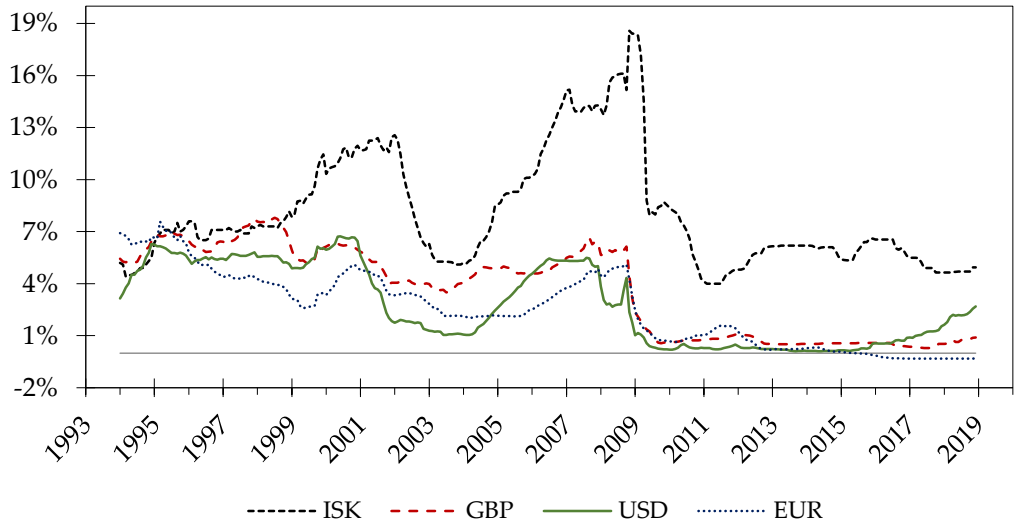

FIGURE 5.2: Short-Term Interest Rates

Foreign exchange rates for the ISK are shown in Figure 5.3, during 2008 the ISK depreciated against all major currencies. From around 2004 exchange rates have moved synchronously in the long- and short-term.

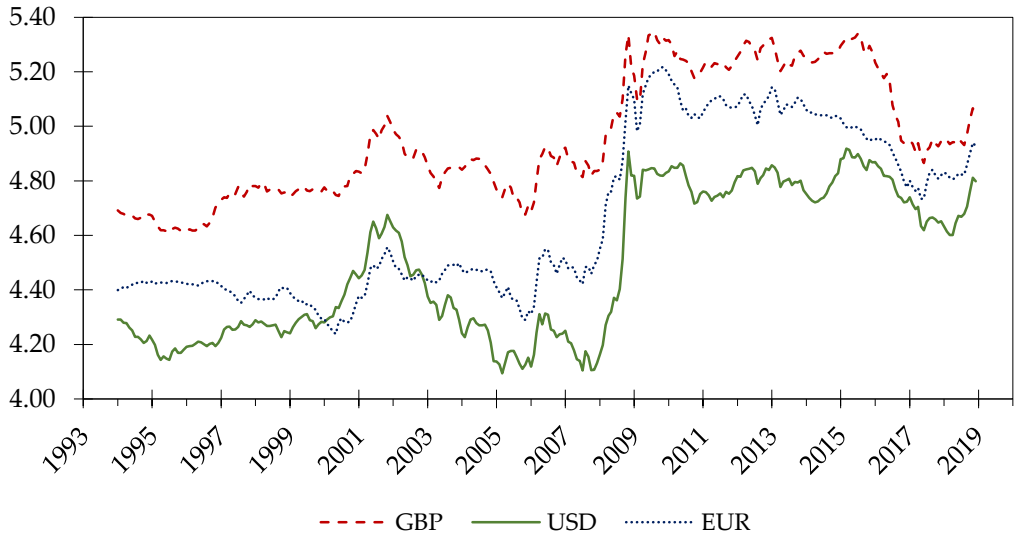

FIGURE 5.3: Foreign Exchange Rates (logarithm)

5.2. Integration Order Determination

The unit root test used to determine the order of integration of variables is the ADF test, as detailed in chapter 4.1. The series are tested for each period and results presented in Tables 5.2 through 5.4. Price levels are tested with a constant and time trend and first difference with constant as indicated by Figure 5.1. Interest rates and exchange rates are tested using a constant in levels and none in first difference, as indicated by Figures 5.2 and 5.3. Unit root test results for the period January 1994 to December 2018 suggest that all processes are integrated of order 1, $I(1)$.

Table 5.2: ADF Test Results for January 1994 to December 2018

	Levels			*First Di erence*		
Variable	Deterministic terms	Lags	Test value	Deterministic terms	Lags	Test value
cpi_{ISK}	constant, trend	12	-2.29	constant	5	-3.97***
cpi_{EUR}	constant, trend	12	-2.03	constant	7	-7.29***
cpi_{GBP}	constant, trend	12	-2.7	constant	9	-6.09***
cpi_{USA}	constant, trend	11	-0.95	constant	10	-5.11***
i_{ISK}	constant	7	-2.3		6	-5.01***
i_{EUR}	constant	3	-2.04		2	-5.83***
i_{GBP}	constant	3	-1.42		2	-6.65***
i_{USA}	constant	10	-2.62*		10	-4.09***
e_{EUR}	constant	9	-1.36		6	-4.51***
e_{GBP}	constant	7	-1.90		6	-4.81***
e_{USD}	constant	2	-1.38		1	-10.36***

Note: ***, ** and * indicate significance level at 1%, 5% and 10% level, repsectively.

The test results from the unit root tests for the periods from January 1994 to March 2008 and December 2009 to December 2018, Tables 5.3 and 5.4 were similar to the whole period test results. In the period prior to the imposition of the capital controls results indicated that variables were integrated of order 1, $I(1)$. Based on these results it is assumed that all the processes are $I(1)$.

Table 5.3: ADF Test Results for January 1994 to March 2008

	Levels			*First Difference*		
Variable	Deterministic terms	Lags	Test value	Deterministic terms	Lags	Test value
cpi_{ISK}	constant, trend	6	-1.49	constant	5	-3.15**
cpi_{EUR}	constant, trend	12	-1.21	constant	7	-5.65***
cpi_{GBP}	constant, trend	12	-2.37	constant	9	-5.62***
cpi_{USA}	constant, trend	12	-1.31	constant	10	-3.53***
i_{ISK}	constant	1	-0.56		1	-6.31***
i_{EUR}	constant	10	-2.49		9	-3.51***
i_{GBP}	constant	3	-2.25		3	-4.78***
i_{USA}	constant	3	-1.88		2	-3.57***
e_{EUR}	constant	1	-1.10		2	-4.32***
e_{GBP}	constant	1	-1.81		1	-7.09***
e_{USD}	constant	1	-1.92		1	-7.69***

Note: ***, ** and * indicate significance level at 1%, 5% and 10% level, repsectively.

Table 5.4: ADF Test Results for December 2009 to December 2018

	Levels			*First Difference*		
Variable	Deterministic terms	Lags	Test value	Deterministic terms	Lags	Test value
cpi_{ISK}	constant, trend	12	-1.65	constant	1	-7.03***
cpi_{EUR}	constant, trend	12	-3.20*	constant	7	-4.49***
cpi_{GBP}	constant, trend	12	-3.67**	constant	5	-2.94**
cpi_{USA}	constant, trend	12	-2.18	constant	10	-3.09**
i_{ISK}	constant	4	-4.28***		6	-2.74***
i_{EUR}	constant	1	-1.13		1	-3.55***
i_{GBP}	constant	7	-2.23		5	-4.2***
i_{USA}	constant	4	3.81		7	-1.96**
e_{EUR}	constant	3	-1.79		2	-5.04***
e_{GBP}	constant	1	-1.10		1	-6.59***
e_{USA}	constant	10	-3.31**		1	-6.19***

Note: ***, ** and * indicate significance level at 1%, 5% and 10% level, repsectively.

5.3. Estimation of Vector Error Correction Models

The estimated models are based on the methodology presented in Johansen & Juselius (1992) for a five dimensional vector for Iceland with two lags ($p = 2$) w.r.t. foreign variables $Y_t = (p_{ISK,t}, p_{f,t}, e_{ISK/f,t}, i_{ISK,t}, i_{f,t})$, where f denotes foreign for the three aforementioned periods. Firstly, the unrestricted model is estimated to investigate whether a long-run relationship exists between variables. Secondly, the relationships are analyzed for the three periods for each economic area. And finally the models are analyzed by restricting the number of cointegrating relations to further interpret the long-run relationship of the PPP and UIP, i.e. if they are at equilibrium by themselves. Recall that absolute PPP suggests that the relationship between domestic and foreign prices, and the exchange rate should be $(a_i, -a_i, -a_i)$ and the UIP suggests that the should be $(a_i, -a_i)$, where a_i is the weight coefficient in Eq. i.

5.3.1. Iceland and the Eurozone

The Johansen test results for the number of cointegrating relationships between Iceland and the Eurozone variables are presented in Table 5.5. These results suggest that for the whole period there exist 2 cointegrating relations, 1 for the period prior to the crisis and 2 to 3 for the period during capital controls. This is interesting as it suggest that there exist more cointegrating relations under capital capital controls than with a floating exchange rate regime.

Table 5.5: Johansen Test Results for Cointegration for Iceland and the Eurozone

	Jan 94-Dec 18		*Jan 94-Mar 08*		*Dec 09-Dec 18*	
H_0	$\hat{\lambda}_{Trace}$	$\hat{\lambda}_{Max}$	$\hat{\lambda}_{Trace}$	$\hat{\lambda}_{Max}$	$\hat{\lambda}_{Trace}$	$\hat{\lambda}_{Max}$
$r = 4$	2.0	2.0	0.6	0.6	6.1	6.1
$r = 3$	11.8	9.8	8.0	7.4	16.8	10.7
$r = 2$	23.5	11.8	21.5	13.6	34.4^{**}	17.6
$r = 1$	55.4^{**}	31.9^{**}	48.0	26.5	66.1^{***}	31.7^{**}
$r = 0$	129.0^{***}	73.6^{***}	88.1^{***}	40.1^{***}	135.6^{***}	69.5^{***}

It was thought to be reasonable that Rank($\mathbf{\Pi}$)=2 for all periods, for a better comparison. Next the error correction vectors, $\hat{\boldsymbol{\alpha}}$, is inspected for the three periods; see Table 5.6. It shows that the adjustment parameter for the exchange rate has the most influence in this relationship in all periods. Influence from Eurozone interest rates and inflation have very small influence on the relationship and are essentially zero. Now by inspecting the cointegrating vectors, $\hat{\boldsymbol{\beta}}$, the PPP is not observed clearly but the estimates for price levels are closely related in the period from January 1994 to March 2008 and the signs are correct, $(a_i, -a_i, -a_i)$, but the exchange rate is rather smaller. The UIP is present in these results but only with correct signs for the whole period and the period during floating exchange rate regime, but under capital controls the signs are incorrect and suggest a distorted financial market.

TABLE 5.6: Long-Run Estimation Results for Iceland and the Eurozone

$\hat{\boldsymbol{\alpha}}$					$\hat{\boldsymbol{\beta}}$				
cpi_{ISK}	cpi_{EUR}	e_{EUR}	r_{ISK}	r_{EUR}	cpi_{ISK}	cpi_{EUR}	e_{EUR}	r_{ISK}	r_{EUR}
January 1994 to December 2018									
-0.008	0.001	-0.019	0.008	0	-0.236	0.473	0.125	1	-0.135
-0.01	-0.004	-0.136	-0.019	0	0.569	-2.09	0.045	1	-4.498
January 1994 to March 2008									
0.016	0.003	0.065	-0.008	0.007	0.779	-1.164	-0.35	1	-0.297
0.023	-0.005	-0.206	-0.01	-0.005	-0.629	0.661	0.438	1	-2.06
December 2009 to December 2018									
0.006	0.007	-0.032	0.046	0	-0.221	0.582	-0.062	1	1.193
-0.031	-0.021	-0.354	0.005	-0.002	1.777	-2.495	0.189	1	3.876

Now the $\hat{\mathbf{\Pi}}$ matrix, Table 5.7, is analyzed for combined effect of the cointegrating relations in each of the five equations in the system. For the whole period the PPP is not present, not even in correct signs. The UIP is present with correct signs for the most part, but never in values. It's interesting to see that Eurozone interest rates and inflation have so much impact for the Icelandic inflation (Eq. 1) and the euro exchange rate (Eq. 3).

For the period prior to the crisis, 1994:M1 to 2008:M3, the PPP and UIP are present

for almost all equations. The PPP has the strongest presence for the exchange rate (Eq. 3) where values are close to the hypothetical ones. The UIP is very close for the Icelandic inflation (Eq. 1) and interest rates (Eq. 4). In comparison with the whole period and the period 2009:M12 to 2018:M12 it's intriguing to see that the exchange rate largely affects the exchange rate to a greater extent when the exchange rate is floating.

In the capital controls period all relationships are highly distorted and no clear PPP or UIP relation is present. This is reasonable as capital controls distort both the goods market and the financial market, and notably the Icelandic inflation has more effect on itself along with the Eurozone inflation and interest rates (Eq. 1) compared to the period prior to the crisis. These results indicate that capital controls not only affect the financial market but also the goods and services market.

TABLE 5.7: $\hat{\Pi} = \hat{\alpha}\hat{\beta}'$ for Iceland and the Eurozone

Eq.	cpi_{ISK}	cpi_{EUR}	e_{EUR}	r_{ISK}	r_{EUR}
			January 1994 to December 2018		
1	-0.014	0.037	0.004	0.024	0.041
2	-0.001	0.007	-0.001	-0.01	0.021
3	-0.096	0.322	0.004	-0.056	0.601
4	-0.002	0.023	-0.005	-0.055	0.09
5	0.001	-0.002	0	-0.001	-0.002
			January 1994 to March 2008		
1	0.002	-0.009	0.003	0.044	-0.054
2	0.006	-0.008	-0.003	-0.001	0.008
3	0.194	-0.233	-0.119	-0.123	0.4
4	-0.002	0.006	-0.001	-0.021	0.024
5	0.01	-0.013	-0.005	0.004	0.007
			December 2009 to December 2018		
1	-0.049	0.061	-0.004	-0.06	-0.156
2	-0.03	0.033	-0.002	-0.052	-0.117
3	-0.661	0.967	-0.076	-0.211	-1.202
4	0.055	-0.133	0.014	-0.202	-0.227
5	-0.003	0.004	0	-0.003	-0.009

5.3.2. Iceland and the United Kingdom

The Johansen test results for the number of cointegrating relationships between Iceland and the United Kingdom variables are presented in Table 5.8. These results suggest that for the whole period there exist 1 to 2 cointegrating relations, 1 for the period prior to the crisis and 3 for the period during capital controls. These results are very similar to that of the Eurozone test results.

TABLE 5.8: Johansen Test Results for Cointegration for Iceland and the United Kingdom

	Jan 94-Dec 18		*Jan 94-Mar 08*		*Dec 09-Dec 18*	
H_0	$\hat{\lambda}_{Trace}$	$\hat{\lambda}_{Max}$	$\hat{\lambda}_{Trace}$	$\hat{\lambda}_{Max}$	$\hat{\lambda}_{Trace}$	$\hat{\lambda}_{Max}$
$r = 4$	0.03	0.03	3.1	3.1	6.4	6.4
$r = 3$	8.6	8.6	8.9	5.79	13.9	7.5
$r = 2$	30.6	22.0	22.1	13.1	41.4***	27.5***
$r = 1$	56.1***	25.5	38.7	16.7	72.6***	31.2**
$r = 0$	114.1***	58.1***	74.0**	35.2**	132.3***	59.8***

As with the Eurozone, it was thought to be reasonable that Rank($\mathbf{\Pi}$)=2 for all periods, for comparison purposes. Next the error correction vectors, $\hat{\boldsymbol{\alpha}}$, is examined for the three periods; see Table 5.9. They show that, like the Eurozone, exchange rates have the most influence for all periods and that inflation and interest rates in the UK could be considered as weakly exogenous as they are essentially zero. Now by inspecting the cointegrating vectors, $\hat{\boldsymbol{\beta}}$, the PPP is only present in correct signs in the period prior to the crisis and values rather close. The UIP is only present with correct signs for the whole period. But as for the Eurozone the period during capital controls shows no trace of these relations.

Table 5.9: Long-Run Parameters for Iceland and the United Kingdom

$\hat{\boldsymbol{\alpha}}$					$\hat{\boldsymbol{\beta}}$				
cpi_{ISK}	cpi_{GBP}	e_{GBP}	r_{ISK}	r_{GBP}	cpi_{ISK}	cpi_{GBP}	e_{GBP}	r_{ISK}	r_{GBP}
January 1994 to December 2018									
0.001	0	0.004	-0.001	0	0.032	-0.109	0.009	1	-0.681
-0.008	-0.004	-0.047	-0.017	0.005	-0.788	0.866	-0.029	1	-7.132
January 1994 to March 2008									
-0.011	0.005	0.002	0.009	0	-0.501	0.821	0.183	1	-2.455
0.011	0.004	0.065	0.004	0	0.277	0.274	-0.614	1	0.794
December 2009 to December 2018									
0.012	0.003	-0.117	0.06	0.003	-0.401	0.572	-0.022	1	0.853
-0.032	-0.015	-0.16	0.013	-0.001	1.912	-2.067	0.145	1	4.429

Now the five equation system resulting from the combined effects of the two cointegrating relations is inspected, the $\hat{\mathbf{\Pi}}$ matrix in Table 5.10. The results for the whole period model shows some UIP relations with correct signs but not so good results for the PPP as the exchange rate seems to have insignificant impact in all relationships. It's worth noting that although the adjustment parameters for the UK interest rates are very small, they have the most impact on the Icelandic inflation and the exchange rate, along with Icelandic interest rates.

For the period prior to the crisis the PPP and UIP are present for most cases with correct signs. It's noteworthy that the PPP is very close in the inflation equation for the UK (Eq. 2) as values are very close to the hypothetical ones $(a_i, -a_i, -a_i)$. But as parameters are very sensitive to model specification one should be careful to jump to conclusions.

For the period during capital controls there are not many significant relations. However, it's interesting to see that parameters for the price level in each country are very close to each other, although exchange rate parameters are rather small in comparison. The interest rate differential suggest, like that of the Eurozone, that financial market was distorted during the capital controls.

TABLE 5.10: $\hat{\Pi} = \hat{\alpha}\hat{\beta}'$ for Iceland and the United Kingdom

Eq.	cpi_{ISK}	cpi_{GBP}	e_{GBP}	r_{ISK}	r_{GBP}
	January 1994 to December 2018				
1	0.007	-0.011	0.001	0.034	0.027
2	0.003	-0.003	0	-0.005	0.028
3	0.041	-0.055	0.003	0.085	0.247
4	0.012	-0.01	0	-0.062	0.152
5	-0.004	0.005	0	0.001	-0.035
	January 1994 to March 2008				
1	-0.008	0.022	-0.003	0.034	-0.047
2	0.006	-0.006	-0.004	-0.005	0.025
3	0.02	0.014	-0.041	0.061	0.062
4	0.01	-0.013	-0.006	-0.014	0.047
5	0	0.001	0	0.001	-0.002
	December 2009 to December 2018				
1	-0.048	0.048	-0.004	-0.062	-0.167
2	-0.025	0.025	-0.002	-0.022	-0.071
3	-0.422	0.496	-0.029	0.131	-0.459
4	0.084	-0.112	0.005	-0.136	-0.071
5	0.002	-0.003	0	-0.009	-0.011

5.3.3. Iceland and the United States

The Johansen test results for the number of cointegrating relationships between Iceland and the United States variables are presented in Table 5.11. These results suggest that for the whole period there exist 1 to 2 cointegrating relations, 1 for the period prior to capital controls and 3 for the period during capital controls. These results are very similar to that of the Eurozone test results, and the same as the UK test results.

TABLE 5.11: Johansen Test Results for Cointegration for Iceland and the United States

	Jan 94-Dec 18		*Jan 94-Mar 08*		*Dec 09-Dec 18*	
H_0	$\hat{\lambda}_{Trace}$	$\hat{\lambda}_{Max}$	$\hat{\lambda}_{Trace}$	$\hat{\lambda}_{Max}$	$\hat{\lambda}_{Trace}$	$\hat{\lambda}_{Max}$
4	1.1	1.1	2.7	2.7	2.25	2.3
3	10.1	9.0	8.87	6.2	13.0	10.7
2	24.5	14.4	23.52	14.6	36.4**	23.5**
1	48.6**	24.2	41.84	18.3	86.3***	49.9***
0	115.8***	67.1***	76.58**	34.7**	161.2***	74.9***

As before, it was thought to be reasonable that Rank($\mathbf{\Pi}$)=2 for all periods, for comparison purposes. Next the error correction vectors, $\hat{\boldsymbol{\alpha}}$, is examined for the three periods; see Table 5.12. They show that, like the Eurozone and the UK, exchange rates are the most influential for all periods and that inflation and interest rates in the US could be considered as weakly exogenous as they are essentially zero. During capital controls however, Icelandic inflation and interest rates have greater influence, something not observed before. Now by inspecting the cointegrating vectors, $\hat{\boldsymbol{\beta}}$, a type of the PPP relation is present prior to the crisis and during capital controls as signs are correct. The UIP is present for all periods, and are close to hypothetical values in the first vector $(a_i, -a_i)$ for the whole period and prior to the crisis.

TABLE 5.12: Long-Run Parameters for Iceland and the United States

$\hat{\boldsymbol{\alpha}}$					$\hat{\boldsymbol{\beta}}$				
cpi_{ISK}	cpi_{USD}	e_{USD}	r_{ISK}	r_{USD}	cpi_{ISK}	cpi_{USD}	e_{USD}	r_{ISK}	r_{USD}
January 1994 to December 2018									
0.001	0	0.003	-0.001	0	0.024	-0.104	0.033	1	-0.795
-0.002	-0.001	-0.016	-0.002	0	2.384	-6.576	0.634	1	-9.526
January 1994 to March 2008									
0.002	0	-0.014	-0.004	-0.001	0.094	-0.253	0.08	1	-1.064
-0.01	-0.002	-0.042	-0.006	0.003	0.873	-2.277	-0.039	1	-3.986
December 2009 to December 2018									
-0.063	-0.006	0.021	-0.148	-0.001	1.262	-2.466	-0.288	1	1.449
0.014	-0.011	0.091	-0.026	-0.005	-4.352	8.211	0.425	1	-9.575

Now the combined effects of the two cointegrating relations of the five equation system are examined, the $\hat{\mathbf{\Pi}}$ matrix in Table 5.13. The results for the whole period model shows the UIP relations with correct sign for almost all equations but the PPP has no presence. It's interesting to see that Icelandic interest rates affect the exchange rate (Eq. 3) the most along with the inflation in the US. The Icelandic inflation (Eq. 1) is affected mostly by the Icelandic interest rates and US inflation, where the exchange rate seems to have insignificant impact.

For the period prior to the crisis there are some PPP relations with correct signs although values are rather small. The UIP is present for the exchange rate (Eq. 3) and the Icelandic interest rates (Eq. 4) and values seem to be close to the hypothetical ones.

For the period during capital controls the PPP relation holds for correct signs for all equations and the UIP for almost all equations. The inflation in Iceland (Eq. 1) is affected mostly by the inflation in Iceland and the US along with US interest rates. Similar bevhaior is observed with the exchange rate (Eq. 3).

TABLE 5.13: $\hat{\Pi} = \hat{\alpha}\hat{\beta}'$ for Iceland and the United States

Eq.	cpi_{ISK}	cpi_{USD}	e_{USD}	r_{ISK}	r_{USD}
	January 1994 to December 2018				
1	-0.004	0.01	0	0.034	-0.009
2	-0.002	0.007	-0.001	-0.008	0.014
3	-0.035	0.091	-0.006	0.1	0.057
4	-0.006	0.018	-0.003	-0.057	0.062
5	0.001	-0.002	0	-0.007	0.002
	January 1994 to March 2008				
1	-0.007	0.017	0.002	0.014	0.015
2	-0.002	0.004	0	0.001	0.006
3	-0.051	0.133	-0.01	-0.191	0.325
4	-0.009	0.023	-0.003	-0.047	0.066
5	0.002	-0.004	-0.001	-0.007	-0.001
	December 2009 to December 2018				
1	-0.124	0.239	0.02	-0.036	-0.207
2	0.041	-0.076	-0.003	-0.015	0.095
3	-0.376	0.708	0.034	0.108	-0.849
4	-0.033	0.072	0.023	-0.144	0.083
5	0.021	-0.04	-0.002	-0.006	0.048

5.3.4. Restricted Cointegrating Relations

The restricted model is used to examine whether the hypothetical PPP and UIP hold by themselves, i.e. without effects from one another. Johansen & Juselius (1992) explained this methodology in their paper but cautioned for using this only as an illustration as misleading results can occur due to the complicated interaction between stationary and non-stationary processes. The hypothesis is tested for whether the PPP, H_{21} = [1,-1,-1,0,0], and the UIP, H_{22} = [0,0,0,1,-1], are stationary by themselves. The results of these restricted models are tested against the result from the unrestricted model, H_1. The likelihood ratio is then compared between the models, which produces a test statistic that is asymptotically distributed as $\chi^2(3)$.

Results for the likelihood ratio comparison is presented in Table 5.14. They indicate that stationarity of the PPP and UIP relations cannot be rejected (bold letters) for the period prior to the financial crisis for all economic areas. This coheres well with the analysis of the $\hat{\mathbf{\Pi}}$'s in previous chapters as the PPP and UIP relations were observed more frequently during that period than in other periods. The PPP and UIP relations by themselves are observed for almost all periods with the US, except for the period during capital controls. This is interesting as that was the only time when all PPP relations were observed in the five equation system, Table 5.13, indicating that there is some relationship between the goods and services market and the financial market during that period.

Table 5.14: Likelihood Ratio Test Results for Restricted models

Economic area	Period	PPP value	UIP value
Eurozone	94:M1-18:M12	17.88 (0.00)	15.51 (0.00)
	94:M1-08:M3	**7.81 (0.05)**	**0.52 (0.92)**
	09:M12-18:M12	19.11 (0.00)	15.05 (0.00)
The UK	94:M1-18:M12	14.44 (0.00)	8.63 (0.03)
	94:M1-08:M3	**2.45 (0.49)**	**0.77 (0.86)**
	09:M12-18:M12	20.78 (0.00)	8.45 (0.04)
The US	94:M1-18:M12	**3.51 (0.32)**	**4.17 (0.24)**
	94:M1-08:M3	**7.59 (0.06)**	**1.93 (0.59)**
	09:M12-18:M12	18.94 (0.00)	**6.7 (0.08)**

6. Conclusions

In this thesis the purchasing power parity and uncovered interest rate parity in Iceland were investigated during different monetary regimes using cointegrated analysis. The monetary regimes under consideration were a period when the Central Bank of Iceland maintained a nominal anchor as the exchange rate and adopted inflation targeting and allowed the exchange rate to float (1994-2008), and during a capital controls period following the 2008 financial crisis and the continuation of inflation targeting (2009-2018). The long-run relationship was examined as there is little literature available on the short-run dynamics for this relationship.

Results for the period prior to the financial crisis are similar to the results obtained by Birgisson Birgisson (2009), as was to be expected. They also indicate that there are more connections with the UK and the Eurozone goods and financial market during this period, in contrast with the US markets. The results regarding the period during capital controls revealed that the PPP and the UIP relations are very weak for the Eurozone and the UK, but rather strong for the US as almost all equations show some type of relations. It‘s hard to say what this means but it might indicate that the Icelandic goods and financial market are more in harmony with the US under capital controls than the other economic areas. A contradiction to what one might think, as Iceland is a part of the EEA and Icelandic financial institutions are more active in the market for euros than the other currencies.

The results for the restricted VECMs indicate that the PPP and UIP is held by itself for all economic areas prior to the crisis, i.e. there exist a long-run equilibrium for the PPP and the UIP by themselves. It's also interesting to see that the PPP and UIP is at long-run equilibrium for almost all periods between Iceland and the US. This is difficult to explain, but the fact that the US dollar is the world's reserve currency might be one of the main determinants of these results.

Overall, these results show that with the freedom of financial flows the economy behaves as predicted by theory, although values are not correct the signs suggest there exist some type of relation for the most part. And that capital controls distort both the financial market and the goods market. For further research of these relationships it would be interesting to use quarterly data, use wholesale price index instead of the CPI, include more variables (e.g. oil price), look at other countries that have experienced a drastic change in monetary policy like Iceland, include an analysis of the covered interest rate parity (if possible) and examine the short-run dynamics.

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A. Table for the ADF test

Table A.1: Critical values for the ADF test

Model & No.Observations	Critical value			
No drift, no trend	0.10	0.05	0.025	0.01
T = 25	-1.60	-1.95	-2.26	-2.66
T = 50	-1.61	-1.95	-2.25	-2.62
T = 100	-1.61	-1.95	-2.24	-2.60
T = 250	-1.62	-1.95	-2.23	-2.58
T = 500	-1.62	-1.95	-2.23	-2.58
T = ∞	-1.62	-1.95	-2.23	-2.58
Drift, no trend	0.10	0.05	0.025	0.01
T = 25	-2.62	-3.00	-3.33	-3.75
T = 50	-2.60	-2.93	-3.22	-3.58
T = 100	-2.58	-2.89	-3.17	-3.51
T = 250	-2.57	-2.88	-3.14	-3.46
T = 500	-2.57	-2.87	-3.13	-3.44
T = ∞	-2.57	-2.86	-3.12	-3.43
Drift, trend	0.10	0.05	0.025	0.01
T = 25	-3.24	-3.60	-3.95	-4.38
T = 50	-3.18	-3.50	-3.80	-4.15
T = 100	-3.15	-3.45	-3.73	-4.04
T = 250	-3.13	-3.43	-3.69	-3.99
T = 500	-3.13	-3.42	-3.68	-3.98
T = ∞	-3.12	-3.41	-3.66	-3.96