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Small National Financial Markets in Transition: The Case of Iceland

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Foreword

This study started as a collaboration between the Institute of Economic Studies at the University of Iceland and Professor Lars Oxelheim at the University of Lund in Sweden. The aim of the study was to try to measure the extent of financial integration between Iceland and the rest of the world. The study was made possible by a grant from the three commercial banks in Iceland and the Central Bank of Iceland.

The study was done by Þórarinn G. Pétursson at the Institute of Economic Studies and Helgi Tómasson at the Department of Economics at the University of Iceland. Oxelheim also provided some valuable comments and data. Very able research assistancy was provided by Jón Þór Sturluson.

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Small National Financial Markets in Transition

The Case of Iceland

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Part I. Introduction

During the last twenty years, financial innovation and sophistication have exploded and had lasting effects on all parts of the world economy. The development of new information techniques, the general process of deregulation and increased intra- and intermarket trade are just few forces that have propelled this development.

One of the main aspects in this transformation process has been the increasing integration of financial markets around the world. Thus, financial transactions have no longer any national boundaries, with each market actor seeking arbitrage opportunities on a number of national financial markets.

The effects of these developments on every sector of the world economy are now well documented. The liquidity explosion at the beginning of the 1970s and the resulting rise in world inflation, how monetary restrictions in the U.S. resulted in corresponding restrictions in Europe, the steep rise in the real USD rate at the beginning of the 1980s, and the turbulence on European foreign currency markets in the early 1990s are just few of many events that give indication of increasing integration of capital markets and free movements of international capital.

The timing of this transformation of financial markets has however been different between countries. The large industrial countries have been on the forefront of this development while the smaller, less developed, countries have followed in their path voluntarely or non-voluntarely, each on it's own pace.

Accepting the hypothesis of almost perfectly integrated financial markets among the large, developed countries, an interesting outstanding question is what progress this integration process has made in the smaller countries with less developed financial markets. This is the goal of our study.

As an example of a small, less developed, financial market, we choose to analyse the financial market of Iceland and its link to the world market. The Icelandic financial market is one of the smallest and probably one of the most undeveloped financial market in western Europe. Iceland has been isolated from foreign influences until just recently. It should therefore be interesting to see to what level this proctectionism has succeeded and whether there is any evident of changes in the last few years. Partly, this follows earlier work by Oxelheim (1990 and 1993), which studies financial integration between Sweden and the global economy and the Nordic countries (except Iceland) and the global economy, respectively, using classical regression methods.

This study contains four parts excluding this one. In part two we begin by defining the concept of financial integration, to make it applicable to empirical analysis. Next we discuss the basic theoretical background needed for our analysis and the results of empirical research on these theories.

Part three contains three chapters. First, we describe the Icelandic financial market, its development during the last decade and the ongoing deregulation process. The second half contains the analysis of the short run dynamics in interest rates and the exchange rate. We analyse the historical patterns in domestic nominal and real interest rates and also look at the development of the Icelandic exchange rate regime, the institutional settings for exchange rate management and the historical pattern in the nominal and real exchange rate. Finally, we analyse how domestic interest rates and the exchange rate have deviated from the hypothetical relations described in chapter two and how these might give rise to risk premiums that we also try to measure.

Part four contains the analysis of the long run properties of interest rates, prices and exchange rates. We begin by introducing the model approach we want to use to analyse financial integration in Iceland and the basic intuition behind our test procedure. This approach is well equipped for detecting long run relationships, in our case between domestic and foreign interest rates and prices, which is of main interest to us. This part also contains the main results of our empirical analysis.

The final part contains some concluding remarks, in which we try to study the implications of our results for financial integration between Iceland and the "global" economy.

We hope that this study will shed some light on the determination of prices and interest rates in Iceland and the effects of increased financial openess on this process.

Part II. Financial Integration

We use this part of our study to introduce and define the basic ideas and tools we want to use later to tackle the problem that lies ahead of us. We begin in chapter one by defining what we mean by financial integration, so as to pin down what is meant exactly by increasing or decreasing financial integration.

In chapter two we start by introducing and discussing three basic theories that we built our basic model on. We then go on to discuss the difficult issues of how to measure the various parts of our model.

1. Defining Financial Integration

During the last two decades financial markets around the world have undergone drastic changes in structure and functioning. With deregulation and increased sophistication, they have become more or less perfectly integrated and globalised.

What would be extremely interesting to do is to try to measure the level of this financial integration. From an economic viewpoint this is important since increased integration and market efficiency will ensure more efficient allocation of resources and should therefore lead to Pareto improvements.

There are three questions that should be asked:

1. To what level are national financial markets integrated with one another?
2. Has financial integration increased in the last two decades or has the process somewhat slowed down?
3. What can we expect in the near future?

To be able to measure financial integration in quantitative terms and whether it has increased or not, one has to define carefully what we mean by it. In this study we follow Oxelheim (1990) by defining three types of financial integration:

Total financial integration. This includes direct and indirect financial integration. Under perfect total financial integration expected real returns are the same between the markets concerned and we have effectively one financial market in the world. If total financial integration is not perfect, the reason can be imperfect direct and/or indirect integration in the financial and goods markets.

Direct financial integration. This is also called capital market integration and is defined from the law of one price for financial securities. If there is perfect direct financial integration the law of one price obtains, so the investor can expect the same return on his investment in different markets, after adjusting for risk. Perfect direct financial integration is synonymous with *perfect capital mobility*. If there are deviations from the law of one price, direct financial integration is less than perfect.

If, however, the deviations are positive but less than or the same as the transaction cost, the markets are still *efficient*, even though they are disintegrated. By efficiency we mean that the market actors have not failed to exploit all risk-free profit opportunities from interest arbitrage between markets, given the information that is available.[1]

Indirect financial integration. This is defined as the situation where the return of investment in one country is indirectly linked to the return on investments in other countries. By indirect we mean that the return on investment is affected through the effects on other markets, for example through the goods market or the foreign exchange market. Note that perfect indirect integration is not the same as perfect substitutability, since it involves assumptions about purchasing power parity (PPP) together with no risk premiums.

One must also distinguish between financial integration and *monetary* integration. By monetary integration we mean integrated foreign exchange markets. A common currency is a strong form of monetary integration, but that does not necessarily indicate financial integration.

Finally, one must distinguish between financial integration of credit markets and financial integration of capital markets. We follow Oxelheim (1990 and 1993) in regarding the capital market as including the credit and stock markets, and the credit market as including the money and bond markets.

According to these definitions we should be able to claim that financial integration has increased if the average level of interest rates on a certain security (with the same characteristics, such as maturity and default risk) converges or if the fluctuations in these rates exhibit increased correlation and move in line with one another. Since it is likely that convergence will take time to have effect, it could also be necessary to look at lagged effects. A decline in the time it takes for foreign interest movements to affect domestic rates should therefore be interpreted as an indication of increased financial integration.

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[1]There are three types of market efficiency according to the amount of information assumed to be available. The first type is the *weak form*, where the information set is assumed to include all relevant past information. The second type is the *semi-strong form*, where the information set is assumed to include all publicly known information. The third type is the *strong form*, where the information set is assumed to include all information that can possibly be known. See Fama (1970).

2. Measuring Financial Integration

In this chapter we discuss some of the measurement problems confronted in any analysis of international financial integration. In particular, we discuss the approach we think is the best to measure financial integration and the theoretical grounds this approach rests on.

Several ways are possible in measuring financial integration, but most of them depend critically on interest rates and capital flows.[2] The first alternative is to measure the interest rate sensitivity of capital flows by looking at the interest rate differential. The second alternative is to measure the reflow of capital and the offset coefficients. The third alternative is to measure the relationship between interest rates in different countries, that is, to study the law of one price for financial instruments and the difference in level and covariation for different interest rate combinations. This is the approach we take in this study.

This approach builds on three very important benchmark theories: the Purchasing power parity theory (PPP), the Uncovered interest rate parity theory (UIP) and the Covered interest rate parity theory (CIP). We now turn to each of these.

2.1. The Purchasing Power Parity Theory

The theory of PPP dates from the late 16th century, but was rediscovered by Gustav Cassel, early in this century. The main idea behind the PPP theory is that the nominal exchange rate is set so that the real purchasing power of currencies is constant over time. That is, if domestic and international goods are perfect substitutes and the goods markets are perfect, no arbitrage profit opportunities will be left unexploited. By perfect goods markets we mean that transaction costs are low, there are no information problems, prices are perfectly flexible and there are no barriers to trade.

Pertaining a broad aggregate of goods, the *absolute* PPP theory requires that the nominal exchange rate equilise the price of a market basket of goods in the two countries. We can therefore see that the law of one price is simply a subcase of the absolute PPP version (i.e. the PPP is just the aggregate version of the law of one price). That is, if the domestic and foreign countries only produce one good and there are no barriers to trade, PPP states that the price of the good will be the same in both countries, denominated in the same currency. If this would not hold, arbitrage profit opportunities would be available, given that the deviations exceed transaction costs.

[2]An alternative approach, due to Feldstein and Horioka (1980), is to argue that if capital was indeed perfectly mobile, domestic investment should not be highly correlated with domestic savings. They find that there is a high correlation, and conclude that capital is not highly mobile after all. Oxelheim (1990) discusses the problems of measuring financial integration with trade flows.

The absolute version of PPP therefore states that the price level in the domestic country is linked to the international price level through the exchange rate in the following manner:

$$(2.1)\quad P_{t+1} = S_{t+1}P^*_{t+1},$$

where P_{t+1} is the domestic price level, S_{t+1} is the nominal spot rate (measured as the domestic price of the foreign currency) and P^*_{t+1} is the international price level. It is common to express this relation in a logarithmic form:

$$(2.2)\quad p_{t+1} = s_{t+1} + p^*_{t+1},$$

where we define lower case letters as logs (i.e. $x_t \equiv \ln X_t$).

Since the real purchasing power of currencies is held constant over time, PPP suggests that in the long run, the rate of change in the nominal exchange rate should tend to equal the differential in the relevant inflation rates between countries. This brings us to another version of the PPP theory, which is usually called the ***relative*** PPP version:

$$(2.3)\quad \dot{S}_t = \frac{\dot{P}_t - \dot{P}^*_t}{(1+\dot{P}^*_t)},$$

where $\dot{S}_t$ is the relative change in the spot rate, $\dot{P}_t$ is the domestic inflation rate between time t and t+1 and $\dot{P}^*_t$ is the foreign inflation rate between time t and t+1.

Taking logarithms of (2.3) we get a more familiar approximation:

$$(2.4)\quad \Delta s_{t+1} = \Delta p_{t+1} - \Delta p^*_{t+1},$$

where we define $\Delta x_{t+1} \equiv (x_{t+1} - x_t)$, which is approximately equal to $\ln \dot{X}_t \equiv \ln((X_{t+1} - X_t)/X_t)$.

Since the composition of market baskets and price indexes substantially varies across countries, many goods are not traded on the international market and because most international transactions are submit to tariffs, it would seem unlikely that the absolute PPP relation will always hold in the real world.[3] However, the relative version only assumes that percentage changes in the exchange rate equal the difference between the percentage changes in the prices of the market baskets of goods in the

[3]Different consumption patterns, differences in quality and differences in listed and transaction prices are other measurement problems that have been mentioned in the literature.

two countries. It could, therefore, be quite possible for the relative version of PPP to hold even if the absolute version does not.[4]

The PPP theory has also been criticised for lacking a clearly specified mechanism that links the exchange rate to the price level and for lacking a specification of the conditions that have to be fulfilled for the theory to hold.

Therefore, it is generally accepted that the PPP theory should be interpreted as an identity in the short run but as an equilibrium condition in the long run. That is, short run monetary non-neutralities, or *transitory effects*, such as those described by Dornbusch (1976), can cause transitory deviations from PPP, without indicating inefficiencies in the foreign exchange market. In the long run, we should however expect these effects to level out and the PPP to hold. It is in these long run properties that our main interest lies.

Most studies find large and frequent short run deviations from PPP.[5] Taylor and McMahon (1988), however, find strong support for the PPP condition as a *long run equilibrium* condition for six major currencies in the 1920s. Using more recent data on the recent floating period, Cheung and Lai (1993), Johansen and Juselius (1992), Juselius (1991) and Camarero and Tamarit (1993) also find favourable evidence for the PPP condition as long run equilibrium relation.

What is common with these studies is that they all use *cointegration techniques*, which allow them to abstract from any short run dynamics that can obscure the long run equilibrium relationship and may lead to a rejection of its existence, even though there is in fact a long run relationship. This could be the reason for the failure of earlier studies, using more conventional methods, to find evidence for long run PPP.[6]

2.2. The Uncovered Interest Rate Parity Theory

Whereas the PPP relationship applies to the goods market, the Uncovered interest rate parity (UIP) relationship applies to the securities market.

One of the cornerstones of the UIP is the famous Fisher equation:[7]

[4]That is, if the factors that cause the absolute PPP to fail are constant over time. See Levich (1985). Many believe, however, that the PPP proposition does not hold in any form. See, for example, Dornbusch (1989).

[5]Oxelheim (1990) and Levich (1985) discuss, among others, earlier empirical evidence on the PPP condition.

[6]As Johansen and Juselius (1992) note, the distinction between the short run and long run dynamics is crucial since we are dealing with two distinct markets, where arbitrage is much less costly in the asset market than in the goods market. The cointegration methodology will be described in detail in chapter 6.

[7]UIP is also called the International Fisher Effect (IFE) or Open Fisher Relationship.

$$(2.5) \quad (1+r_t) = (1+\rho_t)(1+E_t\dot{P}_t),$$

where r_t is the nominal interest rate between time t and t+1, ρ_t is the expected real interest rate between time t and t+1 and $E_t\dot{P}_t$ is the expected inflation rate between t and t+1, conditional on information at time t. Taking logarithms of (2.5), we get a common approximation:

$$(2.6) \quad r_t \approx \rho_t + E_t\Delta p_{t+1},$$

The Fisher equation states that investors will require a nominal interest rate that guarantees them a real return that is adjusted to the inflation they expect over the maturity of their investment.[8] Since the expected real interest rate depends on real phenomena, it can be assumed to change slowly, so we can assume that the expected real interest rates will be approximately constant over a fairly long period of time. It follows that expected changes in the price level will be fully reflected in the nominal interest rate.[9]

The linkage of domestic interest rates to foreign rates is the UIP relationship:

$$(2.7) \quad (1+r_t) = (1+r_t^*)(1+E_t\dot{S}_t).$$

Equation (2.7) states that the difference between nominal returns of the domestic and foreign bonds is exactly offset by an expected change in the nominal exchange rate.[10] The UIP relationship expresses the condition for equilibrium in the capital account. Domestic investors speculating in foreign investments will expect the return of $(1+r_t^*)(1+E_t\dot{S}_t)$. Since risk neutrality is assumed and no transaction costs, we must have in equilibrium that the expected return on domestic and foreign investments equals each other.

Equation (2.7) can also be written in a more familiar way:

$$(2.8) \quad \frac{(r_t - r_t^*)}{(1+r_t^*)} = E_t\dot{S}_t,$$

or by taking logs:

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[8]See Fisher (1930).

[9]The Fisher equation assumes no money illusion and no role for taxes. See Oxelheim (1990) for a discussion on empirical studies on the Fisher equation.

[10]This implicitly assumes risk neutrality among international investors and perfect substitutability between the domestic and foreign bond. Further there is no role for transaction costs and exchange controls. The addition of these components will be discussed in detail later.

$$(2.9)\quad (r_t - r_t^*) \approx E_t \Delta s_{t+1}.$$

This equation forms the basis for our benchmark model as discussed below.

Deviations from the UIP are due to the combined effects of risk premiums and a forecast error. For an efficient market the expected value of the forecast error should be equal to zero, as mentioned before. Smaller deviations would therefore indicate a smaller forecast error (assuming non-changing risk premiums) and, therefore a more efficient market. This can be interpreted as increased financial integration between the relevant countries.

In any sample period, however, the average value of the forecast error need not be zero. There are mainly two reasons for this. First, we have the *Peso problem.*[11] That is, there may be discrete changes in the exchange rate that are expected within that sample period but not realised until later. To put it in another way, the sample distribution of the exchange rate process may not be representive of the true distribution. This can lead to observations of correlated forecasting errors that could wrongly be interpreted as indicating market inefficiency.

Further, Andersen and Risager (1991) point out that the Peso problem can also arise when economic agents face uncertainty about the policy maker's objectives. In a model of endogenous policy they show how, what seems as systematic expectation errors arise while economic agents are updating their information concerning which type of policy maker they are facing.[12] That is, if we have two types of governments, type *a* which does not like devaluations and type *b* that accepts devaluations to gain more competitiveness, the expected depreciation equals:

$$(2.10)\quad E_t \dot{S}_t = (1-\alpha_t)(1-\theta_t)\dot{S}_t^b,$$

where we assume, that the preferred devaluation of type *a* is zero (they prefer fixed exchange rates) and the preferred devaluation of type *b* is $\dot{S}_t^b$. $1-\alpha_t$ is the conditional probability that the government is of type *b* and $1-\theta_t$ is the conditional probability that type *b*, when in office, does devaluate. If type *b* is in government and decides to devaluate the currency, the actual depreciation will equal $\dot{S}_t^b$ but the expected depreciation will be less since α_t and θ_t are between zero and one. Observing government policy, economic agents will continuously update α_t using Bayes' rule.

[11]This is called the Peso problem in reference to the behaviour of the Mexican peso prior to its devaluation in 1976.

[12]The endogenous policy literature was initiated by Kydland and Prescott (1977) and Barro and Gordon (1983), to name the most important contributions.

Hence, at any given date the expected depreciation need not equal the actual depreciation, economic rationality not withstanding.

The second reason, for observable systematic expectations errors, is that market actors may be learning about changes in the environment that have actually occurred. In that case forecast errors may be systematically positive or negative, without market actors being irrational, and thus without indicating market inefficiency.[13]

Finally, by taking the PPP condition, the Fisher relationship and the UIP condition together, we have the equilibrium condition that expected real returns must equal across markets:

$$(2.11)\quad \rho_t = \rho_t^* .$$

This is often called the Real interest rate parity (RIP). RIP can be used to measure whether total financial integration is perfect or not. A rejection of the RIP hypothesis should therefore be interpreted as indicating less than perfect total financial integration. As mentioned before, we take the view that the RIP cannot realistically be expected to hold in every period.[14] However, if we can accept the PPP and UIP as long run relationships, using the cointegration theory, we are able to accept the RIP as a long run relationship, which would give indications of total financial integration in the long run.

2.3. The Covered Interest Rate Parity Theory

The Covered interest rate parity (CIP) combines the UIP relationship with the hypothesis that the *forward rate is an unbiased estimator of the spot rate*. That is, in the absence of risk premiums, market efficiency requires that international investors will use all the available information to form their expectations. We therefore have the efficiency condition that when contracting their forward premium at time t, for a delivery at $t+1$, international investors must use their expectations of the spot rate at $t+1$ to form the forward rate. That is:

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[13]See our discussion about the formation of expectations in 2.4.

[14]Most of the research on the RIP have shown that total perfect financial integration can be denied with some confidence. Frankel and MacArthur (1988) argue that the main reason for the failure of the RIP relation is the lack of goods market integration, rather than the lack of financial market integration. Marston (1993) points out that since we are comparing borrowing costs for two distinct sets of firms who measure nominal interest costs in two different currencies and real costs by deflating by two different inflation rates, there is no simple arbitrage transaction that will eliminate deviations from the RIP relation. These studies all use standard classical regression theory in their analysis and as mentioned above the use of cointegration might give different results.

$$(2.12)\quad F_{t,t+1} = E_t S_{t+1},$$

where $F_{t,t+1}$ is the forward premium quoted at time t, for a delivery at t+1. The hypothesis argues that if the forward rate was not an unbiased estimator of the spot rate, market actors would not be using their current information in an efficient way.[15]

By combining (2.12) with (2.8), we get the CIP:

$$(2.13)\quad \frac{(r_t - r_t^*)}{(1+r_t^*)} = \frac{F_{t,t+1} - S_t}{S_t},$$

or by taking logarithms:

$$(2.14)\quad (r_t - r_t^*) \approx f_{t,t+1} - s_t,$$

where $f_{t,t+1}$ is the log of the forward rate. Therefore, international investors use the observed spot rate at time t, S_t, and the cost of simultaneous borrowing and lending of Eurocurrency deposits in two currencies, $(1+r_t)/(1+r_t^*)$,[16] and use this information to develop the forward rate, $F_{t,t+1}$. This will hold, otherwise there will be unexploited arbitrage profit opportunities through borrowing in one currency, selling it on the spot market for another currency that is then lent, and then buying back the original currency on the forward market. Note that the return on the Eurocurrency is nothing else than $F_{t,t+1}(1+r_t^*)/S_t$, so the CIP indicates that the domestic money market rate should equal the Eurocurrency rate.

The CIP relationship is another approach for measuring direct financial integration. Assuming constant risk premiums, smaller deviations from CIP would indicate increased direct financial integration between the relevant countries. As before, if transaction costs are also taken into account this also indicates increased efficiency in the goods markets.

There are a variety of studies that fail to support the CIP relation.[17] They find significant deviations from it for a number of periods, currencies and assets. Taylor (1986), however, argues that this is probably more due to the fact that earlier studies did not use contemporaneously sampled data and thus did not properly test the CIP condition. He finds very strong support for the CIP condition based on actual market prices of high frequency.

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[15] Assuming, of course, no transaction costs and risk neutrality.

[16] This is called a swap rate.

[17] See Levich (1985) for a survey.

2.4. The Formation of Expectations

What should be fairly obvious from the above discussion, is that expectations play a central role in any study of financial integration. Since no data on expectation formation exists, one has to make an assumption about how the market forms its expectations concerning future variables.

The standard approach during the 1960s and early 1970s was to use Cagan's (1956) *Adaptive expectations.* This approach has since been largely abandoned due to its inconsistency with optimisation behaviour of economic agents. The most widely used approach to day is Muth's (1961) *Rational expectations,* which argues that rational economic agents use all the available information relevant to the particular variable that expectations are being formed about. That is, *on average* the expectations are correct. In a modelling context, this amounts to assuming that economic agents know the structure of the underlying model or, in a stochastic context, that they know its statistical characteristics.

Formally the rational expectations hypothesis argues that the actual observation of the spot rate deviates from it's expected value by a non-systematic forecasting error:

$$(2.15)\quad S_{t+1} = E_t S_{t+1} + \varepsilon_{t+1},$$

where $E_t S_{t+1}$ are the conditional expectations of the spot rate at time t+1. We assume that E_t is equal to the mathematical expectations operator, E. That is, $E_t S_{t+1} \equiv E(S_{t+1}|\Omega_t)$, where Ω_t is the information set that contains all the relevant information available at time t. Finally, ε_{t+1} is the forecast error which is assumed to be distributed as $i.i.d.(0,\sigma_\varepsilon^2)$.

In deterministic models, where there is no explicit uncertainty, the rational expectation hypothesis is equivalent to the hypothesis of *perfect foresight.* That is, we have $\varepsilon_t = 0$, t = 1, 2, ..., and therefore from (2.15) we can see that the actual spot rate will always equal the expected spot rate.[18] This property of the rational expectations hypothesis is a very convenient one and allows us to identify the expected variable with the actual one.

We are aware of the limitations of the rational expectations hypothesis. In particular we acknowledge that the rational expectations hypothesis is really a hypothesis concerning the long run, where all learning has taken place. The rational expectations hypothesis has, unfortunately, little to say about how this learning takes

[18]This outcome of the modelling process should not be viewed as a statement about actual expectation formation. That is, when using perfect foresight, one is not saying that economic agents posess the gift of perfectly forseeing the future in reality.

place. The learning process could, more appropriately, be modelled as following Bayes' rule.

The validity of the perfect foresight (and rational expectations for that matter) as a long run equilibrium can, however, be questioned when there are multiple equilibrium outcomes that are all consistent with rational expectations, such as is the case when there is extrinsic uncertainty (*sunspots*) in the economy. How should economic agents coordinate on which path to follow from many consistent equilibrium paths, that might even be chaotic?[19]

We, however, submit that the rational expectations hypothesis is the only *available* hypothesis concerning expectations formation that can be argued to be consistent with economic theory. Therefore, it will be used throughout this study.[20] It should also be noted that many studies indicate that the exchange rate market is a forward looking market by nature.[21]

Finally, since the market integration hypothesis has two components, an expectations hypothesis and a hypothesis concerning the efficiency of market transactions, the use of the rational expectations hypothesis allows us to concentrate solely on the latter part of the market integration hypothesis.

2.4.1. Previous Attempts to Measure Exchange Rate Expectations

The measurement of the market's exchange rate expectations provides us with both some theoretical and applicational problems. We are, however, able to avoid the problem of making an *explicit* measure of expected exchange rate movements since these are implicit in our multivariate error correction model. This will be further explained in part four of our study. Our only assumption is that of rational expectations.

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[19]For further discussions on perfect foresight along these lines, see Grandmont (1985). For an analysis of sunspot equilibria, see, for example, Azariadis (1981) and Cass and Shell (1983). For a recent analysis of theoretical tests of the rational expectations hypothesis, see Guesnerie (1993). For a model of exchange rate determination that allows for sunspot equilibria, see Manuelli and Peck (1990). They find that the model exhibits multiple equilibria, that sunspots matter, and, that even though money balances are held constant, the equilibrium exchange rate can show considerable volatility that has little implications for welfare.

[20]It is very difficult to test the rational expectations hypothesis empirically because we are really testing two hypothesis. That is, we are testing the validity of the process we assume the variable, we are examining, to take *and*, at the same time, we are testing the rational expectations hypothesis. Therefore, a rejecton of our hypothesis could be because the process we assume is not the true one, and not because of the failure of the rational expectations hypothesis. Furhter, any empirical tests of the rational expectations hypothesis are plagued by the Peso problem. However, Oxelheim (1990) finds evidence in support of the rational expectations hypothesis in a survey among Sweden's largest multinational companies. Other international surveys on exchange rate expectations provide similar results. See Frankel and MacArthur (1988).

[21]See, for example, Mussa (1984).

The problems of making an explicit measure of expected exchange rate movements have been dealt with in various ways in earlier studies. Many of them simply avoided the problem of measuring expected exchange rate movements by comparing Eurorates with the national rate in the same currency. This was done by using the forward rate as an estimator for the expected future exchange rate.

There are, however, several problems with this approach. First, when allowing for transaction costs and a political risk premium it makes the use of forward rate somewhat questionable. Second, since the forward rate is based on interest rate differentials, its use in a study of direct financial integration provides us with some serious multicollinearity problems. The last problem is of course that Eurorates for the Nordic countries have not existed, except for some of them, and then only for short periods. Further, as Oxelheim (1990) points out, in a fixed exchange regime, the forward rate should probably be complimented by the cumulative devaluation potential that may be latent in the form of deviations from PPP.

Another alternative to avoiding to tackle expectations is to assume constant expectations by citing fixed exchange regimes. This allows the problems of measuring expectation variables to be avoided. This is, however, only correct if the exchange rate is *completely* fixed and the regime is considered *credible* by market actors.[22] Both assumptions are, however, questionable. In particular most fixed exchange rate regimes today involve a *target zone*, where the exchange rate is allowed to fluctuate within a given currency band.[23]

Measuring exchange rate expectations in a target zone regime introduces some complications since, as Rose and Svensson (1991) note, it involves expectations of two things: the expected rate of *depreciation* of the exchange rate *within* the exchange rate band, and the expected rate of change in the central parity, or a *devaluation*. The expected total movement in the log of the exchange rate is therefore:

$$(2.16)\quad E_t\Delta s_{t+1} = E_t\Delta c_{t+1} + E_t\Delta z_{t+1},$$

where Δc_t is the log of the change in the central parity and Δz_t is the log of the change in the deviation from the central parity (i.e. $z_t \equiv s_t - c_t$). Following Rose and Svensson (1991) and others we call z_t the exchange rate within the band. The interpretation of

[22]It should also be kept in mind that the probability distributions are likely to be different in fixed and floating regimes. In the fixed exchange rate regime, small expected exchange rate changes have high probabilities and large expected changes have low probabilities. In a floating regime, however, expected changes are distributed over a wide interval of varying probabilities.

[23]The most important contribution to the target zone literature is Krugman (1991). For a recent survey see Svensson (1992).

equation (2.16) is therefore that the expected total rate of depreciation equals the expected rate of realignment plus the expected rate of depreciation within the band.

The expected rate of realignment can then be written as the expected conditional size of the realignment times the probability of realignment:

$$(2.17)\quad E_t\Delta c_{t+1} = \gamma_t E_t(\Delta c_{t+1}|R),$$

where $E_t(\Delta c_{t+1}|R)$ denotes the expected size of realignment conditional upon a realignment between period t and t+1 and γ_t denotes the market's subjective probability at time t of a realignment during the period t to t+1.

The expected change in the exchange rate within the band can also be expanded into two components so as to take account of the possibility that the exchange rate could change its position within the band at a realignment:

$$(2.18)\quad E_t\Delta z_{t+1} = \gamma_t E_t(\Delta z_{t+1}|R) + (1-\gamma_t)E_t(\Delta z_{t+1}|NR),$$

where $E_t(\Delta z_{t+1}|R)$ denotes the expected change in the exchange rate within the band conditional upon a realignment and $E_t(\Delta z_{t+1}|NR)$ denotes the expected change in the exchange rate within the band conditional upon no realignment.

Substituting (2.17) and (2.18) into (2.16) gives us the final expression for the expected movement in the exchange rate:

$$(2.19)\quad E_t\Delta s_{t+1} = \gamma_t E_t(\Delta c_{t+1} + \Delta z_{t+1}|R) + (1-\gamma_t)E_t(\Delta z_{t+1}|NR).$$

That is, the expected rate of change in exchange rate equals the probability of a realignment times the total effective devaluation conditional upon a realignment plus the probability of no realignment times the expected rate of change of the exchange rate within the band, conditional upon that no realignment will occur.

It follows therefore that for measuring exchange rate expectations, it is necessary to measure the expected change in the exchange rate within the band, the probability of a realignment and the expected conditional total devaluation size. Rose and Svensson (1991) avoid the problem of measuring the subjective probability of a realignment by using the UIP relation.[24] The expected exchange rate within the band is estimated assuming mean reversion within the band,[25] and the expected realignment is then estimated as the differential between the interest rate differential and the estimate

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[24]Vikøren (1993) tries to measure the devaluation probability directly by using probit estimation techniques on Norwegian data.

[25]Rose and Svensson (1991) find evidence of a mean reversion within the target zone. See below.

of the expected change of the exchange rate within the band. Rose and Svensson (1991) and Svensson (1991) find that the expected movements of the exchange rate within the band are often substantial (usually between ±5 percent per year) and therefore must be taken into account when measuring exchange rate expectations in a target zone regime.[26]

As mentioned above, if we are to assume constant expectations, the fixed exchange rate regime must be considered credible. Svensson (1990:*a*) has developed a simple test of target zone credibility. He notes that exchange rate bands put restrictions on the interest rate differential. Therefore, if the interest rate differential is outside this rate of return band, and if capital mobility is sufficient and no large capital inflows observable, the exchange rate regime cannot be considered credible. He finds that the Swedish exchange rate regime never had credibility within a five year horizon and occasionally lacked credibility within a one year horizon.

In another recent study, Andersen and Sørensen (1991) find similar results for the other Nordic countries (they do not consider Iceland), especially for Norway and Denmark. As in Svensson (1990:*a*) they find that the credibility decreases with the maturity of the interest rates. Similar results are also found in Svensson (1991), who analysis six EMS currencies relative to the German mark.

Another way to model exchange rate expectations is to use a "no-arbitrage condition":[27]

$$(2.20)\quad s_{t+1} = s_t + v_{t+1},$$

where $E_t v_{t+1} = 0$. Equation (2.20) states that all the relevant information on the future spot rate is contained in the current rate. That is, all unanticipated events are captured in v_{t+1} and the best forecast of the future spot rate is the current rate:

$$(2.21)\quad E_t s_{t+1} = s_t.$$

When we add the assumption that the expected future spot rate is finite, $E_t s_{t+1} < \infty$, then the stochastic process, $\{s_t\}$, is said to be a martingale. A stronger assumption is to maintain that the error term, v_{t+1}, is an *i.i.d.* process. In that case the model in (2.20) is a random walk model.[28]

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[26]A target zone regime was first introduced in Iceland in May the 28th 1993 with the establishment of a foreign exchange market. For this reason we can safely avoid the problem of measuring seperately the expected movements of the exchang rate within the band.

[27]See LeRoy (1989).

[28]A large body of literature finds evidence that the spot rate, at least in the short run, is well approximated by a random walk model. See, for example, Meese and Rogoff (1983) and Meese and Singleton (1982).

The distinction between the martingale model and the random walk model can be important for efficienct market analysis in the light of recent findings of dependency in higher moments for spot rate data.[29] If there is dependency in higher moments, the series s_t would still be a martingale but not a random walk. We would however still have an effient market since it is the martingale property that is important for the efficient market hypothesis.[30]

Lately, there seems however evidence of a rejection of the random walk model, even in the short run for exchange rates in a target zone regime. Rose and Svensson (1991) for the FRF/DEM rate and Svensson (1991) for six EMS currencies relative to the DEM rate, using a theoretical target zone model that allows for stochastic time-varying devaluation risk as developed by Bertola and Svensson (1990), find that the exchange rate band introduces a powerful element of mean reversion in the exchange rate within the band and that the reversion towards the mean increases the longer the time interval between realignments.

Finally, Oxelheim (1990) has suggested that exchange rate expectations consist of two parts, one forward looking part that captures expected future price movements and one backward looking part that captures cumulative deviations of the real exchange rate from its long run equilibrium. He uses the PPP relationship as a basis for expected exchange rate movements, which he argues seems the most intuitively consistent with the rational expectations hypothesis.

To get his expression for expected exchange rate movements, we first define the real exchange rate as:

$$(2.22)\quad \Lambda_{t+1} = \frac{S_{t+1}P^*_{t+1}}{P_{t+1}}.$$

This gives an expression for the log of the expected *nominal* exchange rate movements as:

$$(2.23)\quad E_t\Delta s_{t+1} = E_t(\Delta p_{t+1} - \Delta p^*_{t+1}) + E_t\Delta\lambda_{t+1},$$

where λ_t is the log of the real exchange rate. He assumes that rational individuals will expect the PPP to hold in the long run. It follows then that the expected changes in the real exchange rate, conditional on information available at time t, equal the accumulated deviations from PPP, $-\lambda_t$, since $E_t\lambda_{t+1} = 0$.

A final expression for the expected exchange rate movements is therefore:

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[29]See, for example, Baillie and Bollerslev (1989).
[30]See de Vries (1993).

$$(2.24)\quad E_t \Delta s_{t+1} = E_t(\Delta p_{t+1} - \Delta p^*_{t+1}) - \lambda_t .$$

Assuming perfect foresight, these expected values can be equated with the actual values when it comes to measuring this variable. It should however be kept in mind that forecasting future changes in the nominal exchange rate involves forecasting two different inflation rates and the future changes in the real exchange rate. The forecast error in equation (2.15) can therefore be decomposed into three parts, the error in predicting the domestic inflation, the error in predicting the foreign inflation and the error in predicting the real exchange rate. There are thus three potential expectations errors that might not have zero average values over the sample period, due to the Peso problem.[31]

As mentioned before, Oxelheim's measurement of the expected exchange rate movement has two parts. One is a forward looking part measured by the expected future inflation rate differences. The other is a backward looking part measured by the accumulative deviations from the long run equilibrium real exchange rate. This part captures therefore deviations already observed from PPP, that is the potential depreciation or appreciation of the day. This is well in accordance with the current character of the Icelandic exchange rate regime which emphasis is on stabilising the currency according to a currency basket.

It should, however, be pointed out that since the PPP relationship is really a long run equilibrium relationship, expectations based on PPP are really better suited to generate long term forecasts. For a short term forecast, a simple random walk model might be better suited.

2.6. Risk in International Financial Transactions

For the time being, we will continue to ignore transaction and information costs. What we are interested in discussing now is risk in international trade. The strict PPP, UIP and CIP assume risk neutrality and thus, international investors only care about expected returns. This is, of course, not how the real world works.

There are in general two types of risk, *systematic risk* and *non-systematic risk*. A systematic risk is a risk that an investor cannot diversify from, and will therefore demand compensation for if he is to be willing to invest in that particular project. A non-systematic risk is, however, a risk that investors can diversify from, and will thus demand no compensation for.

Systematic risk can also be divided into several types of risk:

[31]See, for example, Marston (1993) for further discussions related to these problems.

Political risk which attributes to the instability in the situation and the general conditions in different markets. Political risk is said to exist when there is a discontinuity in the decision process that is the result of political changes and that is difficult to anticipate. This includes sovereignty and transfer risk.

Financial risk that attributes to variations in interest rates and capital costs in a given currency. This also includes default risk.

Exchange rate risk that attributes to variations in exchange rates. This also includes inflation risk.

Commercial risk that attributes to variations in relative prices and sales volumes.

Since we are analysing financial integration, we will exclude commercial risk from our analysis. Further, since we have chosen the interest rates in such a way that they are directly comparable we can also exclude financial risk. What is then left is to model the demand for risk premiums for exchange rate and political risk.

We also want to distinguish between *constant* and *variable* risk premiums. This is necessary to be able to determine the size of the market's inefficiency. The constant part can be interpreted as reflecting fairly stable risk, such as the standard deviation of the deviation from PPP. The variable part, however, reflects sources of risk that vary over time.

Finally there could be a trade off between political risk and exchange rate risk. In order to keep a fixed exchange rate mechanism credible, the domestic government will have to rely heavily on fiscal policy. This could include, for example, using capital controls, as Italy and France used extensively in the ERM until recently. Therefore, by reducing the exchange rate risk premium the political risk premium may have to rise.

2.6.1. The Exchange Rate Risk Premium

The most common way to calculate the exchange rate risk premium is to test whether the forward rate is an unbiased estimator of the future spot rate. As explained above, the intuition behind this is that if there is evidence for any systematic forecasting errors, it could be explained by the presence of an exchange rate risk premium. Therefore, we can define the exchange rate risk premium as:

$$(2.25) \quad \mu_t \equiv (f_{t,t+1} - E_t s_{t+1}).$$

The intuition behind this risk premium is that international investors face uncertainty when constructing their expectations of the future spot rate. They will therefore demand a compensation for that risk in the form of a risk premium.

Basically, two approaches have been taken in the empirical literature. The first approach, which seems a natural framework for analysing foreign exchange rate risk, is to use a portfolio model, in which incomplete substitutability between domestic and foreign assets creates a wedge between the respective expected net returns. Domestic agents, that use the returns from their portfolios to buy domestic goods, will therefore only hold foreign assets (assets denominated in foreign currency) when their net return is sufficient to compensate for the risk of holding the foreign asset. The second approach is to use an intertemporal asset pricing model. In both cases the empirical results do not give any clear cut results.[32]

Due to these theoretical and empirical problems in measuring the exchange rate risk premium, there are no clear cut ways to model this premium. But this premium is probably small in relation to the expected change in exchange rates,[33] and therefore the precision in estimating this premium can be assumed to be of minor importance in relation to the uncertainty about how to measure the expected exchange rate changes.

Another problem is that the exchange rate risk premium is probably a function of the exchange rate regime in force. As argued above, exchange rate expectations need not be constant in a fixed exchange rate regime, if the regime lacks credibility. This lack of credibility could therefore lead to a higher exchange rate risk premium in a fixed exchange rate regime than in a floating regime.

Svensson (1990:*b*) shows within a target zone regime, using a model of optimal portfolio allocation, that the nominal and real currency risk premium have two components. The first part is due to exchange rate fluctuations within the band. He argues that since exchange rates are more stable in a target zone (due to the so called "honeymoon" effect[34]) and since the empirical literature has not found significant risk premia, even for free floating regimes, this component should not be expected to be of any significance.[35] This is especially true for more narrow bands.[36] The second part of

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[32]Most studies have found that about 1 percent of the interest rate differential can be explained by this risk premium. See Oxelheim (1990) for a discussion on the empirical results.

[33]See, for example, Frankel and MacArthur (1988).

[34]Krugman (1991) was the first to observe this fact. The intuition behind this is that when a currency moves towards either of the edges of its band it can only move back into the interior and thus stabilises exchange rate expectations if the target zone is credible.

[35]Svensson (1989) finds for Sweden that this risk premium is bounded by only 0.058 percent in the middle of the band and falls towards zero at the edges of the band.

[36]Svensson (1989) shows how the target zone affects the variance of the interest rate differential. He shows that the unconditional variance of the interest rate differential rises when the

the currency risk premium is due to realignments of the band. He finds that this part is probably much larger than the first one, but still of moderate size. For relatively high risk aversion and high expectations of devaluations the risk premium is no more than 20 percent of the total interest rate differential. Svensson therefore concludes that, for narrow target zones at least, disregarding the real and nominal exchange rate risk premium should not be too damaging.

In recent years it has become common to argue that the demand for exchange rate risk premium should not be viewed as contingent on the size of the fluctuations in the nominal exchange rate, but rather on the relative fluctuations in the real exchange rate (fluctuations in the deviations in PPP) for the relevant currencies. As a proxy for the exchange rate risk premium, we take the deviations of the real exchange rate from its long run equilibrium PPP value. In a similar way we find a risk premium for the foreign currencies, and then define the difference of these two as the relative exchange rate risk of the domestic currency:

$$(2.26) \quad \mu_t = \sigma_t - \omega_t,$$

where σ_t and ω_t are the standard deviations in the deviations of the real exchange rate from its PPP value of the Icelandic and foreign currency, respectively. The intuition behind this premium is that as fluctuations of the domestic currency around PPP get smaller, relative to the foreign currency, the risk attached to the domestic currency diminishes. A positive premium indicates that the domestic currency is riskier than the foreign one, and international investors would therefore demand a higher return on domestic investment to keep the expected returns equal.

2.6.2. The Political Risk Premium

According to Oxelheim (1990), political risk includes all risks that a foreign investor faces when investing in a country and risks that are country specific.

Due to increased dependency on international markets, the opportunity set of domestic governments has decreased substantially. This has placed greater burden on the existing policy tools. Should serious imbalances develop in the domestic economy, reduced autonomy of economic policy may prove to be a very inconvenient restriction on policy choices. This could lead the government to use other costly measures, such as capital controls, to regain political autonomy. For an international investor this could prove to be very costly and, therefore, he will demand some compensation for

band is widened and then slowly falls when the exchange rate band gets large. The conditional variance of the interest rate differential is, however, decreasing in the width of the band.

this risk.[37] Generally, this risk generates from the uncertainty that follows when the rules of the game in the country's markets are frequently changed *unexpectedly*. That is, it expresses the premium for political interventions.

Examples of political interventions, that can give rise to a political risk premium, are interest rate and foreign exchange controls. For example, exchange controls can be viewed either as a tax on the return on foreign investment (affecting the return on the investment) or as a restriction on the sums that are allowed to be transferred abroad (affecting the volume of trade). It should, therefore, be clear that unexpected implementation of such controls affects the profitability of investments in the domestic country and international investors will demand a risk premium that will cover them from this risk.[38]

The relative international indebtedness of a country can be viewed as the major source of political risk for the country concerned. This is because rising debt problems seriously reduce the scope of the government for taking economic decisions. This increases the likelihood of restrictions and controls being imposed, which could imply losses to foreign investors, which in return demand compensations in the form of a risk premium.

Since international investors have covered themselves from any exchange rate risk by using the forward market, the only risk remaining is the risk that originates from capital controls, the risk of future capital controls or domestic market interventions. The political risk premium can therefore be defined as the deviation from CIP:[39]

$$(2.27)\quad \pi_t \equiv (r_t - r_t^*) - (f_{t,t+1} - s_t).$$

In estimating the political risk, we proceed in two ways. The first one is to identify the number of days the rules of the game have been changed in the domestic country. Political changes that indicate deregulation are, however, not included. The logic behind this approach is that international investors demand a risk premium that is based on their past experience that will compensate them for current capital controls and the risk of future capital controls. This measure is therefore capturing the

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[37]Studies of corporate decision making have shown that international investors take this risk very seriously and have high aversion to this risk. See Oxelheim (1990).

[38]Although few countries use capital controls today, the mere possibility of them reverting to measures "in the case of emergency" (as allowed by the emergency clauses in OECD's capital liberalisation agreement) is enough for international investors to demand a risk premium.

[39]An alternative way would be to measure the political risk as a mark-up against LIBOR for the relevant country.

reputation of the policy maker.[40] If the government has intervened substantially in the past, foreign investors will acknowledge that fact and are more likely to demand a premium for that risk.[41]

The second approach is to use the indebtedness of the domestic country, relative to the international indebtedness, as a proxy for political risk. This premium can be calculated on a basis of the country's gross international indebtedness, its net foreign assets, or some other measures of financial difficulties. This measure is therefore capturing the *need* of the policy maker to intervene in the market, or the risk of future interventions.

Taking these premiums together can therefore yield a measure of a political risk premium that catches the two main reasons for foreign investors to demand a political risk premium, the history of policy interventions and the risk of unexpected future interventions.

2.7. Transaction Costs

Up to now we have not considered transaction costs. Transaction costs are the costs that market actors have to pay for various transactions on the international financial market. If the foreign exchange market is efficient and market actors risk neutral, transaction cost would be the only real cost of using the foreign exchange market. If this is to hold, transaction costs could easily be measured by the average value of deviations from CIP, after eliminating the values from speculative periods. Since we allow for the possibility of inefficiency in the foreign exchange market and risk aversion, this approach does not seem appropriate for our study. It should, however, be viewed as an upper limit on the measure of transaction costs.

One alternative to measure the transaction cost is to use the *bid-ask spread* (the spread between the spot purchase and the selling quotation). This type of spread measures the cost of buying an asset and then selling it immediately. That is, the transaction cost is:

$$(2.28) \quad \tau_t^s = (S_t^a - S_t^b)/S_t^a,$$

where τ_t^s is the cost of this spot transaction, S_t^a is the ask price and S_t^b is the bid price. Since the differential actually includes two transactions (the cost to the bank of buying

[40]This reputation could, of course, be modelled with Bayesian updating, similar to that of exchange rate expectations.

[41]We assume that he has a 24 month memory, so the demand is based on what happened during the last 24 months. See Oxelheim (1993).

immediately and of selling later), the spread should be divided by two to measure the spot transaction cost.

Empirical results using the bid-ask spread vary considerably across currencies and over time. For example, they indicate that transaction costs are substantially higher in periods of floating exchange rates. But a substantial number of spreads in the range of 0.25% to 0.5% have been reported.[42]

This has, however, been argued to be only one component of the total cost of transacting since it ignores the costs of producing financial claims, the cost of gathering information, etc.

Another way to measure transaction costs is to use the *triangular arbitrage*. That is, we compare actual exchange rates with a rate calculated from triangular arbitrage. For example, if we have the £/$ rate, we can compare it with the £/$ rate we get from a transaction via a third currency, i.e. (£/¥)(¥/$). The idea behind this is that if the transaction cost between the currencies is the same, the upper limit of the deviation from triangular parity should equal the cost of the corresponding bilateral transaction.

Studies using the triangular arbitrage indicate higher transaction costs than those indicated by the bid-ask spread. This is because estimates using the triangular arbitrage include the costs of monitoring the deviations from the triangular parity.[43]

2.8. Measurement Questions

When testing a hypothesis concerning international integration of financial markets, many measurement problems arise. These problems must be dealt with before we carry on with our analysis.[44]

The first problem concerns the information we assume that international investors have at the time of acting. One of the problems in most earlier studies of financial integration is the use of *ex post* outcomes to measure *ex ante* quantities. These studies are hard to interpret since we cannot say that market actors have been acting in an inefficient way based on actual outcomes, when their information set only contained *expectations* concerning these actual outcomes. We deal with this problem by assuming rational expectations, which provides a formal way for linking actual outcomes with their expectations. However, when interpreting our results the Peso problem must always be kept in mind.

[42]See Oxelheim (1990) and Levich (1985).

[43]The triangular arbitrage can often overestimate the transaction cost, since it often produces the cost of two transaction. As Levich (1985) points out, even though the use of the triangular arbitrage seems preferred, it is plagued by severe estimation problems.

[44]A more detailed description of our data is in appendix 1.

A second problem concerns the choice of interest rates to use. Basically we want the securities in our study to reflect all the same characteristics except those concerning the jurisdiction involved and the currency in which they are denominated. We must, therefore, find foreign securities that have similar risk, maturity and other relevant characteristics as the domestic ones to be studied.

The most common rate used in international studies of direct financial integration is the treasury bill rate, since it exhibits the greatest international similarity as regards instrument-specific risks such as default and liquidity risk. Other candidates could be, for example, money market bond rates, discount rates, prime rates or government bond rates. We use all these interest rates, although we restrict our attention to the government bond rate in our cointegration analysis. It should, however, be stressed that our main results where *not* sensitive to the choice of interest rate variable.

Even though directly comparable rates have been found, there still remains a problem where government regulations have controlled the interest rates rather than market forces. In this case government interventions can produce deviations from international rates in the long run which would indicate imperfect financial integration in our cointegration analysis.

A third problem is the definition of the "foreign rate". Following Oxelheim (1990 and 1993) we argue that the influence of U.S. interest rates on their European counterparts has considerably decreased since the collapse of the fixed exchange rate agreement in the middle of the 1970s. In fact there seems now to be a mutual causality between U.S. rates and the major European rates, as partly mediated by the Eurodollar rate.

For this reason it has become custom in recent years to use multilateral rather than bilateral rates as a measure of the foreign rate. This multilateral rate, a so called "global" interest rate is usually described as a weighted average of the interest rate in the largest OECD countries or the countries corresponding to each country's currency basket. Acknowledging the possibility that the U.S. interest rate was a good measure of the global rate at the beginning of our study, we use the U.S. rate and our weighted measure of the global rate parallel in our study.

The choice of a weighting procedure provides, however, a problem for using a multilateral interest rate. For a small open economy it is a critical choice. The question is, should trade weights or capital weights be used? Trade weights seem more appropriate since it can be assumed that capital market weights covariate with the interest rate. We use trade weights therefore in our study.

A fourth problem concerns the choice of a base year when calculating indices. This is an important choice since the choice of equilibrium point obviously affects any interpretation of observations away from that equilibrium point. In general we choose 1979 as our equilibrium point. The reason for this choice is that in that year the export industry where in a reasonable balance, the real exchange rate close to its PPP equilibrium and the current account close to being balanced.[45]

A final point concerns the starting point of our study and the frequency of the data we want to use. When describing the Icelandic financial market, our period of study is 1974 to 1992. We choose as a starting point the year 1974, in light of the collapse of the Bretton-Woods system. In the cointegration analysis however our initial year is 1978:12 for our monthly data and 1979:I for our quarterly data since data on some of our variables was not available for the earlier years.

The choice of a time aspect is also important for any study of financial integration, since arbitrage and speculation are a question of hours and minutes. Due to the lack of such a high frequency data for all our variables a more infrequent time aspect has to be chosen.[46] We use monthly and quarterly data parallel in our study and compare the results from these data sets. It should be pointed out that both sets of data gave similar results, although the monthly data was less favourable in terms of misspecification tests of the residuals, such as normality tests. This is, of course, because of the large variability in the monthly data.

[45]In most other studies of Icelandic exchange rates, 1979 or 1980 have been chosen. See Guðmundsson (1987).

[46]For an analysis of international interest rates with such a high frequency data, see, for example, Taylor (1986). He collected spot and forward rates with ten minutes interval for three days in the London foreign exchange market.

Part III. The Icelandic Financial Market

The Icelandic financial market has undergone some drastic changes in recent years. Not only has the internal structure of the market been changed rapidly towards market orientation, but it has also gradually been opened to international competition. This restructuring of the domestic financial market is an ongoing process.

In this part we look at some of the main aspects of the Icelandic financial market and the institutional changes that have been undertaken in recent years. We also analyse the development of domestic interest rates and the Icelandic exchange rate development. Finally, we analyse the premiums for political and exchange rate risk.

3. The Development of the Icelandic Financial Market

3.1. Towards More Competition and Greater Efficiency

The Icelandic financial market is a rather undeveloped market although it has grown considerably in the last ten years. Until very recently it was heavily regulated and financial instruments remained few and unsophisticated. Due to the political atmosphere and some peculiarities in the domestic economy it was thought that the market could not distribute resources in the most desirable way nor the most efficient.

Due to these reasons, the credit market has been segmented, so that the banks have remained on the short end of the market while investment funds have been the main supplier of long term credit. Most of the investment funds have been owned by the government, traditionally with separate funds for each industry, which supplied loans on subsidised prices through politically decided channels. Majority of the banking market was also government owned and segmented according to respective industries. However in 1989 one of the government owned bank was taken over by three private banks which established a new private bank, Íslandsbanki. In 1990 the largest government owned bank, Landsbanki, took over a small private bank, so now there are three large commercial banks, two government owned and one private bank.[1] In addition there are also 33 saving institutions, of which most of them are very small. In 1991 the total market share in banking (measured as the share of total loans and deposits) of the government run banks was 57 percentages of the total market, the private bank had 25 percentages of the market and the saving institutions the final 18 percentages.

[1]Compared to three government run banks and four private banks in 1988.

The segmentation between commercial banking and investment banking is thought to be slowly disappearing. Commercial banks and saving institutions are gradually starting to supply long term credit and merging of the investment funds into one large investment bank has been proposed. There are also discussions about privatising both of the government run banks, starting with Búnadarbanki and then turning to Landsbanki. The first step would be to change them into corporations, wholly owned by the government, and then gradually selling the shares to private businesses. This is all part of the process of getting the domestic financial market prepared for more international competition.

Until 1979 the market was very thin. Few interesting financial possibilities existed and private savings were very little. Iceland has a history of very high inflation and that, and the fact that interest rates where determined by the government, led to diminishing private financial savings. Real interest rates were often substantially negative, as discussed further in chapter four. This led to an imbalance in the credit market, with excessive demand, disequilibrium credit rationing, and a decreasing belief in monetary assets. To fulfill the excessive demand for loans substantial foreign borrowing was undertaken. Most foreign borrowing went through the commercial banks, which would then distribute it to the market.[2]

Facing these problems the government decided to start a widespread indexation of monetary holdings in 1979 (financial indexation of government bonds had started as early as 1956 to some extent), that led to increased savings and a more stable financial market. Interest rate indexation has been very widespread, with approximately one third of deposits and loans of banks and saving institutions indexed and about seventy percent if bond issue is also included. With gradually declining inflation (one of the lowest in the OECD countries this year) there have been discussions of abandoning this widespread indexation, but there is still a danger of decreasing private savings that are still relatively low.[3] The banking sector has however been pressing for changes in the indexation laws. They argue that they are exposed to inflation risk as they are only allowed to index loans that have longer maturity than three years but all deposits can be indexed. There is therefore a mismatch in indexed loans and deposits which make the banks exposed to inflation risk. The Central bank has recently tried to decrease this risk by offering the commercial banks intererest rate swaps.

[2]Foreign money is about one third of commercial bank lending in Iceland, which should give indications of the substance of these lending.

[3]There are also discussions of taxing capital income, which has been tax free in Iceland. The argument is that since inflation has decreased a tax on capital income should only be fair. Again, one should be careful, especially as capital is now more or less free to move abroad, since savings could decrease further.

In February 1984 the first steps toward market determined interest rates were taken when interest rates on six month deposits and interbank credit were given free. In August that same year almost all other interest rates were liberalised, although the Central Bank could still intervene if interest rates were thought to be "too" high for some reason.[4] This changed in November 1986 when a new law was passed that declared that interest rates in Iceland where now formally fully market determined. The Central bank could therefore only affect the interest rate through its standard market instruments.

The first years of market determined interest rates were difficult. Due to the lack of money- and bond markets there was little trade with bonds. The reason for this was that the treasury and commercial banks used its access to the Central bank to generate funds, rather than on the bond- and interbank market, respectively. It was not until 1990 that these markets really started functioning and it can therefore be said that interest rates *effectively* became market determined at the start of the 1990s.

The regulatory change in interest rate determination led to an introduction of many new financial instruments. New financial firms developed, with new brokerage firms, mutual funds and leasing companies and subsequent trade in bonds and equities.

Since interest rates became market determined, real interest rates have remained positive in general. This led to difficult adjustment problems for many Icelandic firms, which had for many years been able to get loans with negative real interest rates. This caused many to argue again for political intervention in the determination of interest rates. Due to this political pressure a new law, stating that the Central bank was allowed to intervene in interest rate determination, was passed in September 1988. This law has, however, never been acted on.

In the last three years the domestic financial market has been developing rapidly. Some new instruments have been introduced, such as currency and interest rate options, currency and interest rate futures and currency and interest rate swaps. Since new markets started to emerge, the nature of monetary policy has also changed drastically. Before, the government had direct and automatic access to funds at the Central bank, but this was changed in June 1992 with an agreement between these two parties. This greatly enhanced the Central bank's control over monetary aggregates and meant that the government had to turn directly to the domestic financial market for funds. That, along with increased use of open market operations on the secondary market by the Central bank to affect the interest rate level, has helped the market to develope.

The financial market has also slowly been preparing itself for increased international competition. The recent restructuring in commercial banking has already

[4]Which they did in the beginning of 1985 when the Central bank lowered credit rates.

been mentioned: the development in privatisation, merging and the establishment of new financial firms. Other important developments such as the interbank market, the equity market and the foreign exchange market have emerged. These new institutions have meant a drastic change in the domestic financial market, which is slowly strengthening the market and the compatibility of its participants. There are however few aspects that need to looked into in the near future. To name only four, we mention:

- There are no Icelandic firms registered on foreign stock markets;
- Private placements abroad are relatively unknown;
- Foreign holdings of Icelandic krona is very small;
- Icelandic holdings of foreign assets is very small.

Oxelheim (1993) identifies six phases that financial industries around the world have gone through. These are:

1. The protective phase;
2. The deregulation phase;
3. The competition phase;
4. The reregulation phase (a phase of reregulation of an explicitly prudential nature);
5. The excess capacity phase;
6. The consolidation phase.

According to Oxelheim the global market had reached phase 5 in the beginning of the 1990s. The next phase, which is now in process in many countries, is a one of consolidation, which involves intra- and intersector consolidation. This transition can be painful however.

Oxelheim argues that the Danish market has reached phase 5, while the Norwegian and Swedish markets are in a transition from phase 3 to phase 4 and the Finish market has just left phase 2. In the report of Hagfræðistofnun (1993) it is argued that Iceland has also just recently left phase 2. It is also argued that the Icelandic financial market has roughly gone through the same development as other financial markets, only that the Icelandic market is about 5 to 10 years behind. This offers an opportunity for Iceland to learn from the difficulties other countries have gone through.

As Oxelheim (1992) points out, the completion of the external deregulation in the Nordic countries at the beginning of the 1990s (a little later for Iceland) means that they are all exposed to the problems of phase 5.

3.2. Major Market Actors

As mentioned before, the Icelandic financial market has been a rather thin market, with few market participants. There has, however, been a drastic change in the last few years that can only be described as revolutionary. The opportunity set of savers has greatly increased. Before, the only saving opportunities where bank deposits and government bonds. Since then, especially after the development of brokerage firms, a variety of saving instruments have emerged, such as equity, bank bonds, treasury bonds, government guaranteed housing bonds and various private bonds.

The major market actors are:[5]

Commercial banks

There are three banks; two of them owned by the government, which hold 57 percentages of the banking market measured as the share of total loans and deposits, and one is a private bank that holds 25 percentages of the market. The largest single bank is the government owned Landsbanki which has about 39 percentages of the market. As a share of financial intermediation, the commercial banks and savings institutions have about 34 percentages of the total credit outstanding.

Saving institutions

There are 33 saving institutions, most of them are very small. The share of total loans and deposits of the saving institutions is about 18 percentages. The three largest saving institutions have about 10 percentages of the market.

Investment credit funds

The investment funds receive borrowing authorisation in the government's Credit Budget, which comes with an explicit government guarantee. The investment funds channel credit towards long term investment, which is typically to a specific industry. These funds have also been exempt from corporate taxes and prudential capital standards. There are now 13 investment funds operating in the Icelandic financial market. Many of them are quite small and very weak financially. Measured in

[5]Information on market shares and other data are for 1992 and is taken from the Banking inspection of the Central bank of Iceland (1993): "*Viðskiptabankar, sparisjóðir, eignaleigufyrirtæki, verðbréfafyrirtæki og verðbréfasjóðir*". Data for the pension funds are from the Banking inspection of the Central bank of Iceland (1993): "*Lífeyrissjóðir*". Data for the investment funds are from the Central bank of Iceland (November 1993): "*Hagtölur mánaðarins*".

outstanding loans, the two largest investment funds have about 50 percentages of the long term credit outstanding, while the five largest have about 83 percentages of the long term credit outstanding. The total share of the investment funds of total credit outstanding is about 25 percentages.

Pension funds

By the end of 1992 there where 84 pension funds operating in Iceland. Many of them are very small and have run into serious operational problems. In recent years there has been some development towards merging and some funds have been closed. It is also evident that many funds will have problems in meeting their future obligations towards their members. The total assets of the three largest pension funds are about 33 percentages of the total and the share of the 10 largest is about 56 percentages. Of the total credit outstanding, the pension funds have about 12 percentages.

Brokerage firms

The first brokerage firm in Iceland was established as early as 1974 but the market really started with the development of mutual funds in 1986. The market developed fast and market returns remained high for the first years. There are now five registered brokerage firms operating on the domestic financial market. Of these, three are partially or wholly owned by the commercial banks and saving institutions and one owned by a foreign firm. The largest brokerage firm has about 30 percentages of the market, measured in total assets, and the three largest have about 75 percentages of the market.

Mutual funds

The first mutual fund was established in 1985 and started to operate in 1986. There are now eight mutual funds, which are divided into nearly 30 divisions, operating through the five brokerage firms. The market share of the three largest funds, of which each is operated in a separate brokerage firm, is nearly 50 percentages.

Leasing firms

The first leasing company was established in 1986. Today there are five registered leasing firms. The market share of the largest leasing firm is about 30 percentages followed by three other with over 20 percentages market share and one small leasing firm with 1 percentages of the market.

The treasury

This is the largest market actor, and has been the market leader. The fact that the government has run a huge deficit has had large effects on the market. The subsequent demand for funds has made it difficult for the Central bank to bring down interest rates that have been very high.

3.3. Towards Deregulation of International Financial Transactions

As has already been pointed out, many changes have occurred on the Icelandic financial market in recent years. In general this can be described as a gradual change from a heavily regulated market towards a free and more competitive market. This process of deregulation started more or less in the late 1980s and is expected to be finished in the end of 1995.

Iceland was a rather late starter in the process of liberalising capital movements, both within the country and international financial transactions. The liberalising process was gradual in its nature and did not really catch momentum until the 30 of July 1990, when a new law on capital movements was passed. Until that, capital movements where heavily regulated, especially outward movements of capital. This new bill stated that capital movements where to a large extent free, although some supervision was still thought to be needed. This new bill also stated that almost all of these regulations left should be abolished by the end of 1993.

The process of deregulation can be summarised as follows:

Direct investment

Inward

Until the 15 of December 1990 inward direct investment were not formally banned, but several regulations made these infeasible. For example, authorisation by the Central bank was needed for foreigners to be able to move the return on their investment abroad. This requirement was abolished with the new law in 1990. The new law also applied to asset returns, that were originated in Iceland, and foreigners were allowed to invest in domestic industry. Foreign investment in fisheries and the energy industry are however prohibited and in banking and the transport industry they are restricted.

Outward

Direct investments abroad were subject to authorisation by the Central bank. With the new law investments in foreign industry were possible without a given permission by the Central bank. These investments were, however, subject to a maximum amount, which gradually increased until the restrictions were totally abolished in the end of 1992.

Investment in real estate

Inward

Formally, foreigners were not restricted from buying real estate in Iceland. They were, however, restricted by laws on residency that stated that only Icelandic citizens could own real estate in Iceland. With the new law these investments became unrestricted.

Outward

Icelanders were not allowed to invest in real estate abroad unless given permission by the Central bank. Permission was generally given if these investment were thought to support domestic industry. With the new law, Icelanders were allowed to invest in foreign real estate without the Central bank's permission. These investments were, however, subject to a maximum until the end of 1992.

Portfolio investment

Inward

No formal laws denied non-resident issuing of foreign equity. Restrictions were, however, in exchanging the residual into foreign currency, which was subject to a permission by the Central bank. These were abolished with the new law. All trade must though be channeled through domestic authorised security dealers.

Domestic residents were unauthorised to issue loans to foreigners without permission. Exporting industries were allowed to issue trade credit according to custom in international trade. These were abolished with the new law.

Finally, the new law allowed investment in foreign bonds and equities but only in long term securities. These were also subject to a maximum amount of 750 thousand

ISK. These restrictions will be abolished by the end of 1993. By that time investment in short term bonds will also be allowed but only up to a certain maximum amount, which is 1 million ISK for individuals and 175 million ISK for security traders. These restrictions will then be abolished by the end of 1994.

Outward

With the new law Icelandic firms were allowed to issue equity abroad. These were, however, subject to a certain maximum amount that would gradually increase and become totally unrestricted by the end of 1992.

Borrowing abroad by domestic industry was restricted and subject to permission by the Central bank. The amount allowed to borrow was generally linked to actual trading. Foreign borrowing not linked to international trade was not allowed unless with permission from the Ministry of Commerce.

With the new law domestic residents were allowed to take foreign loans with maturity of no less than one year. This restriction will be abolished by the end of 1993 when domestic residents will be allowed to take short term loans, even though they are not linked to actual trade. Until the end of 1994 these will be restricted to a maximum of 5 million ISK.

Deposits

Inward

No formal laws restricted non-residents to have deposits in Iceland. The exchange to foreign currency was however subject to permission by the Central bank. With the new law this became unrestricted.

Outward

Deposits in foreign banks were not allowed unless for firms in the transport and insurance industries. With the new law domestic residents were allowed to keep deposits in foreign banks of a maximum of 3.75 million ISK. This restriction will be abolished by the end of 1993.

4. Interest Rate and Exchange Rate Trends

In this chapter we analyse historical patterns in Icelandic interest rates and exchange rates. We show that the Icelandic financial market has been peculiar in many aspects. Nominal interest rates have been held fixed for long periods and real rates have been volatile and often negative. We also see that the value of the Icelandic krona has deteriorated against all foreign currencies over the period of our analysis.

4.1. The Development of Domestic Interest Rates

As was discussed in chapter three, the determination of domestic interest rates was a centralised process ruled by the Central bank, and not by market forces. This becomes obvious when we look at the rates of some of the main securities on the Icelandic financial market. The change towards market determination is reflected in new interest rate patterns, which, as we will see later, are more in line with international patterns.

The fact that the Icelandic financial market is very undeveloped means that few types of securities have developed in the market. It is only in the last few years that new types have started to emerge. This, of course, will make comparison with foreign rates more difficult.

Here, we look at four types of securities, three types of short term rates and one type of long term rate.[1] The first short term rate we look at is the *official discount rate*. This rate exists on a monthly basis for the whole period of our study, that is from 1974 to 1992.

The second short term rate is the *treasury bills rate*. This rate exists on annual basis from 1987 and on monthly basis only from 1990.

The last short term rate is the *prime rate* (the lending rate to first class borrowers). Since prime rates where not offered on the domestic financial market until 1990, we use the general short term commercial rate minus 1.7 percent, which is the average difference from the prime rate in 1990 to 1992. This rate exists on a monthly basis for the whole period.[2]

The long term rate we use is the *government bond rate*. This is the yield on government bonds with five year maturity. This rate exists on annual basis for the whole period, but only since 1990 on monthly basis.

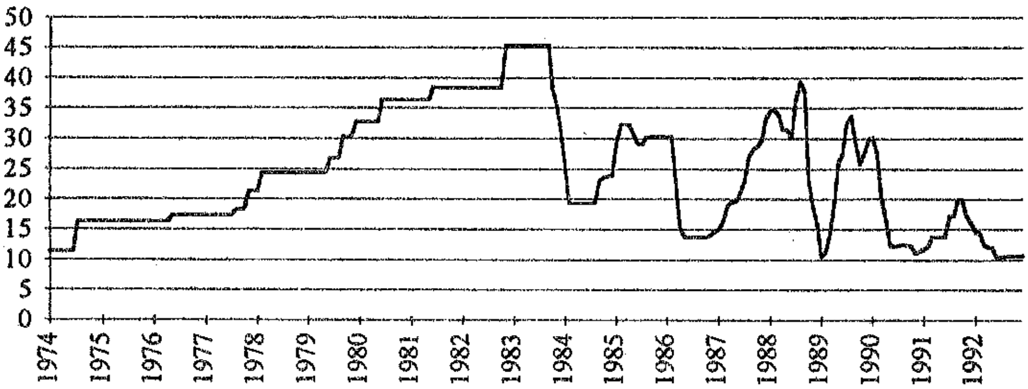
[1]The sources of our domestic and foreign data are discussed in appendix 1.
[2]The difference remained very stable over the period.

4.1.1. Historical Patterns of Nominal Interest Rates

Nominal rates reached their historical peaks in the early 1980s. This can be seen in figures 4.1 - 4.3, which shows average annual nominal prime rate, the government bond rate and the discount rate in Iceland from 1974.

Figure 4.1. The development of the nominal prime rate; 1974-1992

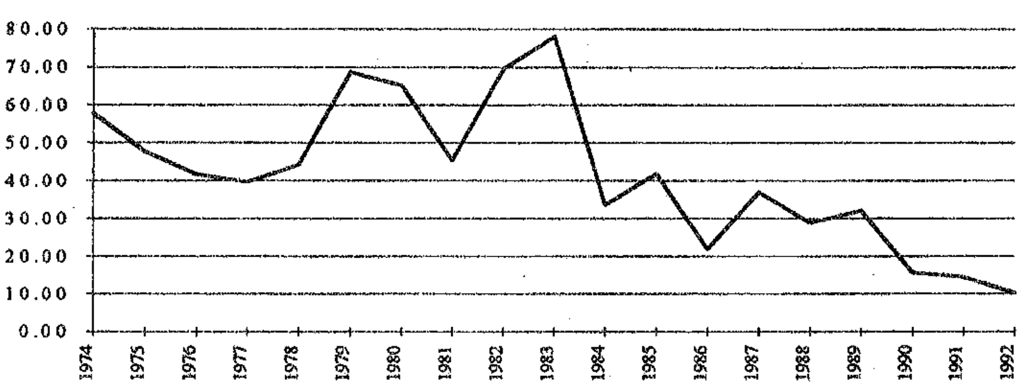
Percentages per year, monthly data, end of period observations



The prime rate increased steadily until 1984, where it reached its peak. After that, it fell substantially but became much more volatile. However, it became more stable in 1990.

Figure 4.2. The development of the government bond rate; 1974-1992

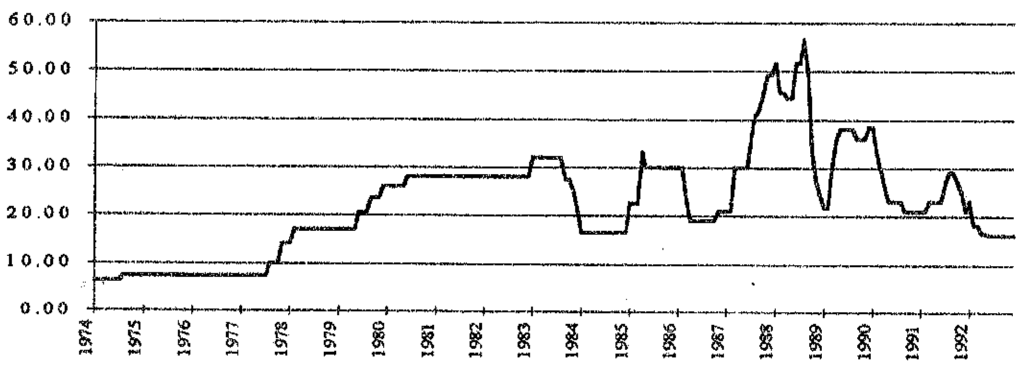
Percentages per year, annual data



The government bond rate follows a similar trend as the prime rate. It increased steadily until 1984, where it started to decrease.

Figure 4.3. The development of the discount rate; 1974-1992

Percentages per year, monthly data, end of period observations

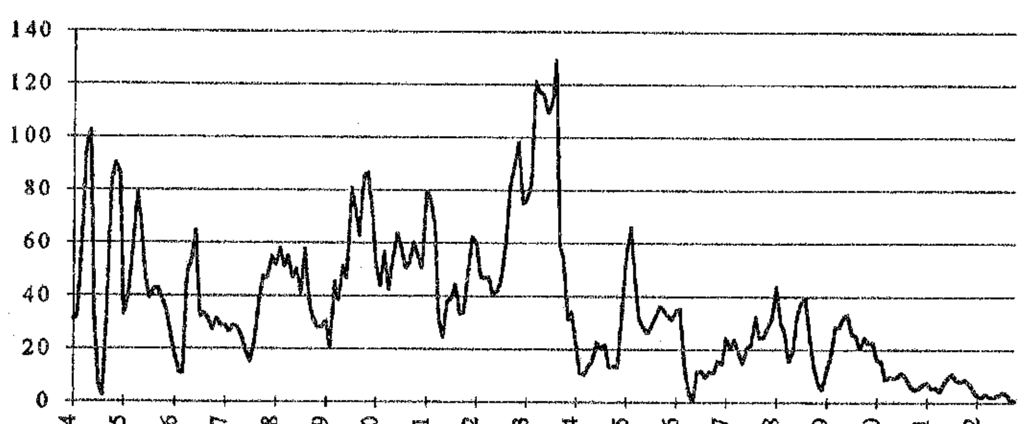


The discount rate also increased steadily until 1984, and became very volatile after that. Unlike the other rates it does not seem to have decreased, although some reduction can be detected since 1990.

In general, nominal interest rates were rather stable in 1974-1983, but a positive trend is obvious. This follows from the fact that these rates where not market determined and that inflation was generally increasing in that period and reached very high levels in the early 1980s, as can be seen in figure 4.4.

Figure 4.4. The development of inflation; 1974-1992

Percentages per year, quarterly data



After 1984 nominal rates became much more volatile, as perhaps should be expected, but these fluctuations seem to have reduced in the 1990s. This can be seen clearer when we look at the evolution of the mean of these rates and their standard deviations around the mean.

In table 4.1 we report the mean and the standard deviation from mean of the four types of interest rates. We also divide the period into three subperiods. The first period is 1974 to 1983. In that period the domestic financial market remained heavily regulated and undeveloped with centrally decided interest rates. The second period is 1984 to 1989. In 1984 interest determination was changed towards the market and gradual deregulation started. The final subperiod is 1989 to 1992. In that period new markets started to develop and many new instruments emerged.

Table 4.1. Mean and standard deviation of nominal interest rates; 1974-1992

Percentages per year, monthly data, end of period observations

1974 - 1992

Series	Obs	Mean	Std Error	Minimum	Maximum
ISPRN	228.000	24.293	9.900	10.500	45.300
ISDRN	228.000	22.444	10.916	6.250	56.400
ISTBN	49.000	17.530	6.567	8.600	28.000
ISGBN	226.000	35.663	18.108	8.130	105.829

1974 - 1983

Series	Obs	Mean	Std Error	Minimum	Maximum
ISPRN	120.000	27.096	10.529	11.300	45.300
ISDRN	120.000	18.027	9.525	6.250	32.000
ISGBN	120.000	46.304	17.037	17.698	105.829

1984 - 1989

Series	Obs	Mean	Std Error	Minimum	Maximum
ISPRN	72.000	24.557	7.386	10.500	39.300
ISDRN	72.000	29.925	11.192	16.500	56.400
ISTBN	13.000	26.635	1.043	25.500	28.000
ISGBN	72.000	28.620	7.847	11.467	49.907

1990 - 1992

Series	Obs	Mean	Std Error	Minimum	Maximum
ISPRN	36.000	14.419	4.551	10.500	30.100
ISDRN	36.000	22.206	5.308	16.000	38.400
ISTBN	36.000	14.242	4.105	8.600	26.700
ISGBN	34.000	13.021	2.878	8.130	19.388

When we look at table 4.1 we can see that the mean of the discount rate increased in the period 1984 to 1989, but has since decreased. The mean of the prime rate and the government bond rate have, however, gradually diminished for the whole period.

In measuring the volatility of the interest rates we choose to look at their standard deviations. For the discount rate we see that standard deviations increased from the first subperiod to the second, but has since decreased. The standard deviations of the prime rate and the government bond rate have gradually been decreasing but it has increased for the treasury bills rate from the second subperiod to the third.

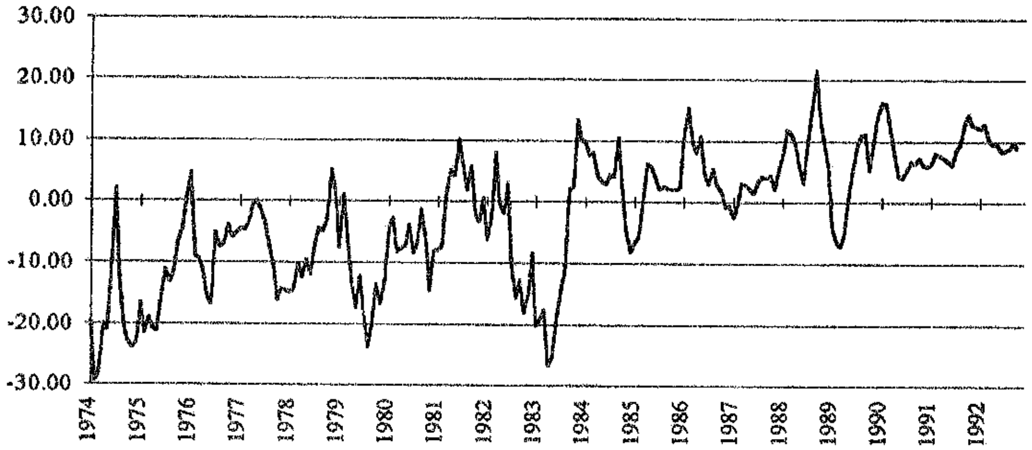
It is noteworthy that Oxelheim (1993) reports the same facts for the other Nordic countries. The volatility of nominal interest rates seems to have increased in general for the period 1974 to 1989, but decreased after that. However, when the standard deviations are compared it seems that Icelandic interest rates have remained much more volatile in general for the whole period. This is due of the very high and volatile inflation in Iceland and the undeveloped domestic financial market.

4.1.2. Historical Patterns of Real Interest Rates

In general, real interest rates have risen substantially in Iceland since the latter part of the 1980s.[3] This can be seen in figures 4.5 and 4.6, which show the real prime rate and real discount rate since 1974. There it can be seen that both those rates where substantially negative until 1984, when gradual adjustment towards market determination started. After 1984 they have mostly remained positive and have often been very high. Finally, for the whole period they have been rather volatile.

Figure 4.5. The development of the real prime rate; 1974-1992

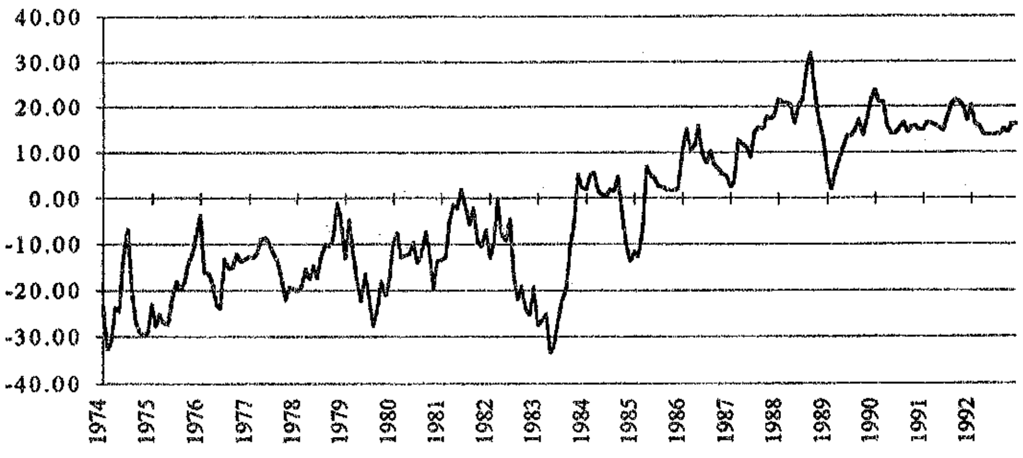
Percentages per year, monthly data, end of period observations



[3]To calculate the real interest rates we use the Fisher relation (equation 2.5). But since that relation includes expected values, we have to approximate those using the rational expectations hypothesis. It should be obvious, that this assumption will make the expected real interest rate identical with the actual *ex post* real interest rate.

Figure 4.6. The development of the real discount rate; 1974-1992

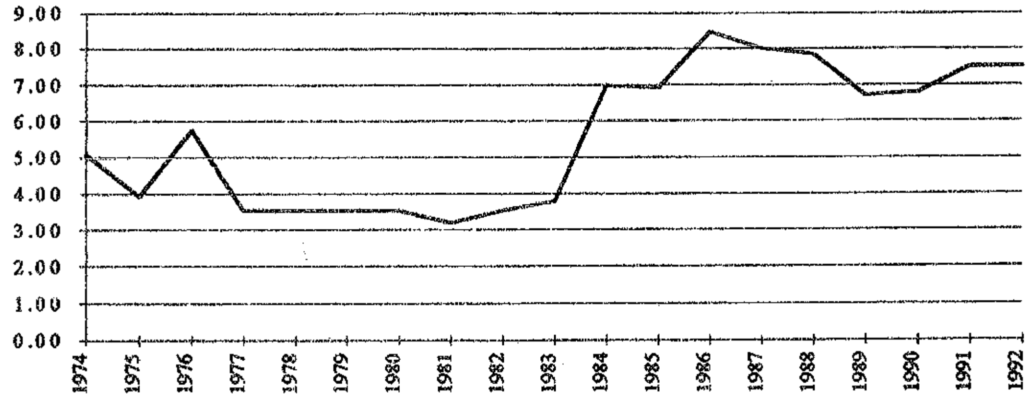
Percentages per year, monthly data, end of period observations



In figure 4.7 the real yield on government bonds is shown. This rate remained rather stable for the whole period but rose somewhat in 1984 and remained high until 1989, where it fell. Since then it has risen steadily.

Figure 4.7. The development of the real government bond rate; 1974-1992

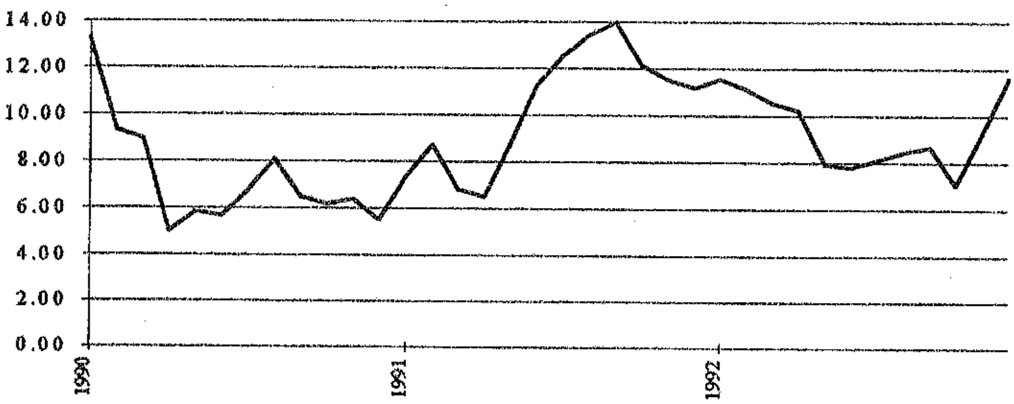
Percentages per year, annual data



In figure 4.8 we see the real rate of treasury bills for the years 1990 to 1992. There it is seen that the rate remained low until 1991 where it started to rise.

Figure 4.8. The development of the real treasury bills rate; 1990-1992

Percentages per year, monthly data, end of period observations



This can also be seen when we look at table 4.2 that shows the mean and the standard deviation of the real rates.

Table 4.2. Mean and standard deviation in real interest rates; 1974-1992

Percentages per year, monthly data, end of period observations

1974 - 1992

Series	Obs	Mean	Std Error	Minimum	Maximum
ISPRR	226.000	-1.944	10.623	-29.375	21.482
ISDRR	226.000	-2.809	15.900	-33.432	31.723
ISTBR	47.000	8.319	4.914	-9.649	15.378
ISGBR	228.000	5.746	2.061	3.200	9.900

1974 - 1983

Series	Obs	Mean	Std Error	Minimum	Maximum
ISPRR	120.000	-8.998	8.942	-29.375	13.365
ISDRR	120.000	-15.479	8.309	-33.432	5.154
ISGBR	120.000	3.941	0.777	3.200	5.750

1984 - 1989

Series	Obs	Mean	Std Error	Minimum	Maximum
ISPRR	72.000	4.607	5.758	-8.066	21.482
ISDRR	72.000	9.146	9.238	-13.696	31.723
ISTBR	13.000	6.775	8.438	-9.649	15.378
ISGBR	72.000	7.853	0.845	6.700	9.900

1990 - 1992

Series	Obs	Mean	Std Error	Minimum	Maximum
ISPRR	34.000	9.078	3.173	4.012	16.273
ISDRR	34.000	16.593	2.767	13.661	23.691
ISTBR	34.000	8.909	2.543	4.998	13.975
ISGBR	36.000	7.550	0.625	6.600	8.500

There we see that the mean of the real discount rate was highly negative for the first subperiod, but has since been raising steadily in the latter two subperiods. The mean of the real prime rate was also negative in the first subperiod, but has since remained positive. For the real government bond rate, we see that the mean rose from the first to the second subperiod but has since remained approximately unchanged. Finally, the mean of the real treasury bill rate increased from the second to the last subperiod.

Looking at the standard deviations, we see that for the real prime rate it has steadily been declining. The standard deviation of the real discount rate has, however, risen between the first and the second subperiod, but then declined substantially in the last period. The standard deviation of the real government bond rate has been very small and stable over the whole period. Finally, the standard deviation of the real treasury bills rate declined from the second to the third subperiod.

Thus, on a whole, we find that real interest rates often remained negative before 1984, but have since rose above zero and have often been quite high. We also find that real interest rates have been very volatile over the whole period, although the volatility seems to be declining in the last three years of our sample. This, again confirms what Oxelheim (1993) finds for the other Nordic countries.

Comparing nominal and real interest rates also indicates that real interest rates have, for the prime rate and discount rate, remained in general more volatile. This is surprising, since from the Fisher relation we get that:

$$(4.1) \quad \mathrm{var}(\rho_t) = \mathrm{var}(r_t) + \mathrm{var}(E_t \Delta p_{t+1}) - 2\,\mathrm{cov}(r_t, E\Delta p_{t+1}) \approx 0 .$$

Thus, the Fisher relation indicates that the expected real interest rate should be fairly stable and that the instability of the inflation rate should be reflected in the nominal interest rate. Our data seem, therefore, not to support the conjecture that the expected real interest rate should be more or less constant. This is in line with other empirical studies of the Fisher relation.[4]

Looking in general at real interest rate trends in Iceland it is obvious that a structural change occurred in 1984. Before that date, real interest rate where generally substantially negative and rather volatile. This is not surprising, taking account of how interest rates where determined before that period and that inflation were very high and volatile in that period as is seen in figure 4.4. That would indicate that the Fisher relation did not hold before 1984.

[4]See Oxelheim (1990) and (1993) for a survey. The empirical failure of the Fisher effect does not necessarily indicate that it does not hold, it could be that our assumption concerning expectations was rejected by the data, rather than the Fisher effect per se.

After 1984, however, real interest rates became positive and although they remained rather volatile, they became much more stable than before. That is, the validity of the Fisher relation increased after 1984. Our data supports this conjecture, since the volatility of real interest rates has decreased significantly, especially in the last subperiod.

These rather unstable real interest rates are rather worrying. Fluctuating real interest rates tend to make economically efficient decisions by firms and households more difficult and can increase the number of "wrong" decisions, which will hurt the economy in the long run.[5]

4.2. The Development of the Icelandic Exchange Rate

Since the start of the 1990s a major structural change has occurred in the Icelandic exchange rate mechanism. There are two major changes that are of notice. First, the currency basket was changed. Until the 1 of January 1990 the currency basket was constructed as a three year moving average of trade figures. The currency basket therefore involved 17 currencies of Iceland's major trade partners. In the beginning of 1990 this changed when the weight of the ECU currencies was increased. The currency basket now consists of ECU (76 percentages), USD (18 percentages) and JPY (6 percentages). The development of the currency basket can be seen in table 4.3. With this structural change the weight of the European currencies of ECU increased substantially from 57.6 in the end of 1991 to 76 percentages. This is sensible in light of the development of increased trade between Iceland and the EC and with the ratification of the EEA treaty. In light of these developments many economists in Iceland are arguing for a full pegging to ECU.

[5]Oxelheim (1993), for example, finds a significant negative relation between fluctuations in the real interest rate and the stock exchange index of Swedish firms.

Table 4.3. The development of the Icelandic currency basket; 1988-1991

Percentages

	1988	*1989*	*1990*	*1991*	*Average*
USD	26.77	23.18	19.97	18.23	22.14
GBP	14.34	14.65	15.18	15.52	15.47
CAD	0.36	0.34	0.35	0.37	0.35
DKK	6.70	6.88	6.99	6.87	6.89
NOK	4.50	4.93	5.23	5.06	5.13
SEK	5.06	5.10	5.34	4.98	5.35
FIM	2.23	2.18	2.05	1.89	2.21
FRF	3.89	4.52	4.73	5.23	4.12
BEC	2.04	1.88	1.67	1.56	1.94
CHF	2.22	2.06	2.28	2.73	2.40
NLG	5.18	4.85	4.66	5.07	5.12
DEM	12.20	12.86	13.44	14.13	12.89
ITL	2.55	2.74	3.16	3.23	2.97
ATS	0.35	0.38	0.41	0.42	0.39
PTE	3.72	4.27	4.51	4.12	4.01
ESP	2.55	2.27	2.18	2.12	2.22
JPY	5.34	6.91	7.85	8.47	6.39
Total	100.00	100.00	100.00	100.00	100.00

Source: Central Bank of Iceland.

The second major change in Iceland's exchange rate mechanism was the introduction of a foreign exchange market on 28th of May in 1993. This led to a change in the determination of the domestic exchange rate with an introduction of a target zone regime. After that the krona became market determined for the first time, with the Central bank only being able to affect the exchange rate through operations on the foreign exchange market. The exchange rate policy pursued by the Central bank is to allow the exchange rate to fluctuate within a ±2.25 percentage band. By setting the effective exchange rate index equal to 100 on 31st of December 1991, the upper and lower bound on 28th of May 1993 where set at 108.78 and 104.0. During the first two weeks the exchange rate index remained steady, its highest value being 106.42 and its lowest 106.33. Following the turbulence on the exchange rate markets in June the government decided to depreciate the krona by 7.5 percent that led to a realignment of the bands that are now set at 117.6 and 112.3.

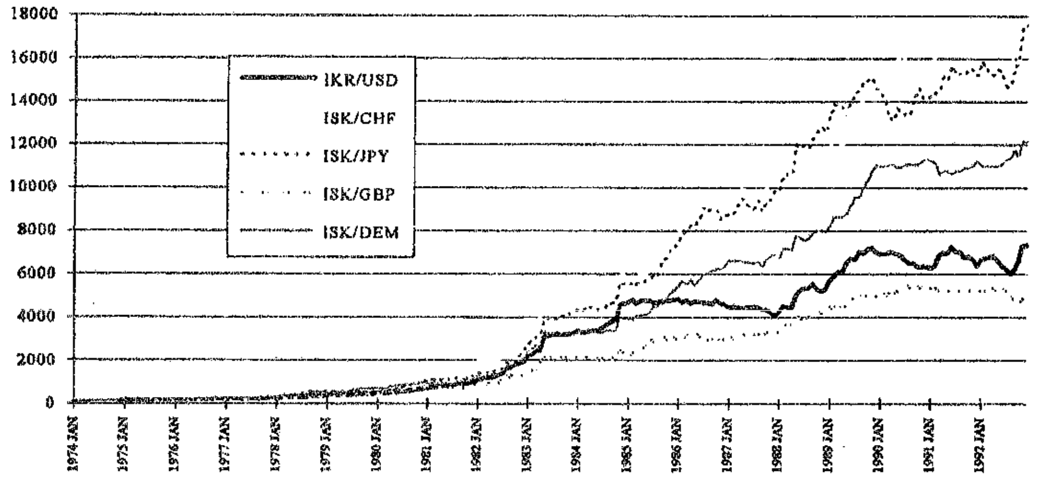
Before this, the exchange rate was determined solely by the Central bank on the morning of each day. Bilateral exchange rates where determined by the rates of the relevant currencies on the London foreign exchange market. The Central bank was forced to buy all currency on those terms during the whole day without any relation to quantity, changes in relative prices or market position. Due to this system Icelandic commercial banks and the Central bank were severely exposed to currency risk since market actors had an opportunity of a riskless arbitrage simply by following the development of foreign exchange rates that could change within the day whereas these rates where fixed in Iceland for the whole day. This risk was however substantially diminished with restrictions on capital movements.

4.2.1. Historical Patterns in the Nominal Exchange Rate

When we look at the development of the nominal value of the Icelandic krona in terms of the USD, CHF, JPY, GBP and DEM, in figure 4.9, we see that the value of the ISK has deteriorated substantially.

Figure 4.9. The development of the nominal exchange rate; 1974-1992

ISK/foreign currency, monthly data, index = 100 1974:1



This decline in value is greatest against JPY and CHF, but against all of them the decline is enormous to put it mildly. This shows how weak the Icelandic krona is and that the government has not been too concerned about its value. This can also be seen from table 4.3 that reports official changes in the exchange rate from 1970. There we see that the Icelandic krona has officially been depreciated 29 times since 1970. The longest periods of officially fixed exchange rates is the period November 1984 to February 1988, February 1975 to February 1978 and December 1989 to November 1992.

Table 4.4. Official changes in the Icelandic exchange rate since 1970

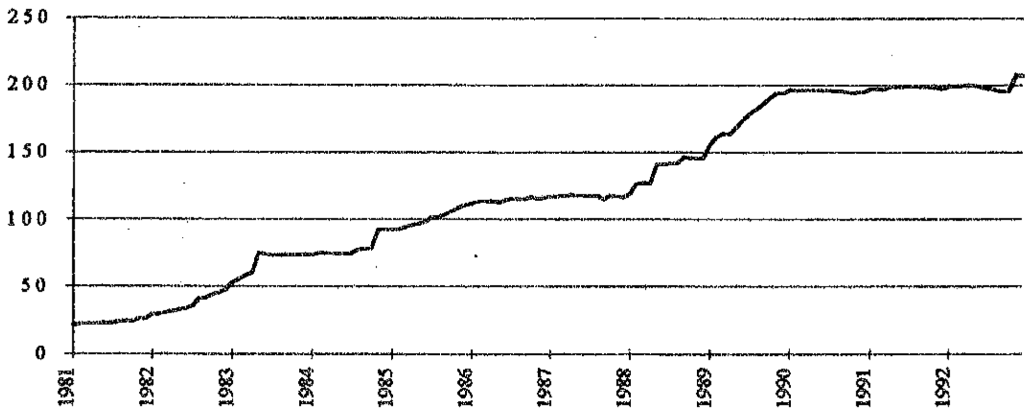
Date		*Changes, in percentages*	Date		*Changes, in percentages*
December	1972	10.7	August	1982	13.0
February	1973	10.0	January	1983	9.0
April	1973	-6.0	May	1983	14.6
September	1973	-3.6	November	1984	12.0
May	1974	4.0	February	1988	6.0
September	1974	17.0	May	1988	10.0
February	1975	20.0	September	1988	3.0
February	1978	13.0	January	1989	4.88
September	1978	15.0	February	1989	2.5
March	1980	3.0	May	1989	1.5
February	1981	3.5	June	1989	2.25
May	1981	3.85	July	1989	2.25
August	1981	4.76	September	1989	2.25
November	1981	6.5	December	1989	2.25
January	1982	12.0	November	1992	6.0
			June	1993	7.5

Source: Felixson and Jónsson (1989) for 1970 - 1988 and new data from the authors. Negative numbers indicate appreciations.

This development can also be seen in figure 4.10, which shows the effective nominal exchange rate for the period 1981 to 1992. There we see that even though the official exchange rate regime has been that of a fixed exchange rate the krona has been devalued substantially against its currency basket.

4.10. The nominal effective exchange rate of the ISK; 1981 - 1992

Monthly data, index, currency basket



From the figure it can be seen that the longest periods of a fixed effective exchange rate are May 1983 to November 1984, January 1986 to February 1988 and January 1990 to November 1992.

Finally, table 4.5 reports the mean and the standard deviations of the monthly percentage changes in the price of the ISK against the same currencies as before.

Table 4.5. Mean and standard deviation of the exchange rate; 1974-1992

Monthly percentage changes in the ISK/foreign currency

1974 - 1992

Series	Obs	Mean	Std Dev	Minimum	Maximum
GBP	227	1,829	4,748	-8,189	28,788
USD	227	1,998	4,411	-5,166	25,758
DEM	227	2,229	4,513	-8,143	28,868
CHF	227	2,393	5,061	-12,848	30,997
JPY	227	2,414	4,935	-9,343	30,694

1974 - 1976

Series	Obs	Mean	Std Dev	Minimum	Maximum
GBP	35	1,567	6,262	-4,555	28,349
USD	35	2,369	5,388	-1,835	25,758
DEM	35	2,760	6,085	-5,880	28,868
CHF	35	3,292	6,557	-4,936	30,997
JPY	35	2,473	6,312	-2,990	30,694

1976 - 1988

Series	Obs	Mean	Std Dev	Minimum	Maximum
GBP	143	2,344	4,846	-5,117	28,788
USD	143	2,450	4,470	-4,068	25,017
DEM	143	2,610	4,612	-8,143	21,995
CHF	143	2,666	5,196	-12,848	26,116
JPY	143	2,844	5,059	-9,343	24,335

1989 - 1992

Series	Obs	Mean	Std Dev	Minimum	Maximum
GBP	47	0,330	2,383	-8,189	6,620
USD	47	0,732	3,382	-5,166	10,229
DEM	47	0,902	1,968	-4,722	5,789
CHF	47	0,770	2,222	-3,924	5,256
JPY	47	0,734	2,811	-4,787	8,903

There we can see that the mean change in the bilateral exchange rate is positive on the whole and for all of the subperiods, indicating a depreciation of krona against all the currencies on average over the whole period. In general, the depreciation of the krona seems to increase in period 1976 to 1989, compared to the period 1974 to 1976. After 1989 the price of the krona has, however, been much more stable. We can also see that over the whole period, the average depreciation of the krona has been largest against JPY, over 2.4 percent a month on average, and smallest against GBP, over 1.8 percentages a month on average.

Looking at the standard deviations, we see that in all cases and all of the periods, the standard deviations in the change of the bilateral rates have been very high. We see, however, that the volatility of the krona has diminished. Looking at each currency, we see that for the whole period the ISK/CHF rate has been the most volatile and the ISK/USD rate the most stable. In recent years, it seems, however, that the ISK/USD rate has been the most volatile but the ISK/DEM rate the most stable. This is what we should expect since the USD rate was very volatile in the latter part of the 1980s and, as mentioned before, the current Icelandic currency peg includes the ECU where the German Mark is the major currency, whereas the USD weighted more before.

In figure 4.11 we show the distribution of bilateral monthly exchange rate changes for the Icelandic krona. These figures can be viewed as showing the probability distribution of the ISK against the foreign currencies. Positive outliers indicate depreciation of the krona. Looking at the figure, we see that these distributions are quite similar for all of the currencies, with regard to the central value, dispersion, skewness and peakedness. We can see from the figure that the histograms exhibit considerable skewness. This results from the inflationary history of Iceland and the predominant tendency of the krona to depreciate. This is also in line with other empirical results which report that the distributions for currencies which experience similar monetary policies tend to show no skewness while dissimilar policies tend to generate skewness.[6]

It can also be seen these distributions exhibit fat tails, i.e. the probability distributions have more probability mass in the tails than normal, Gaussian probabilities. This is also in line with a well documented stylised fact, reported in de Vries (1993). The reason for this is that extremely high and low realisations occur more frequently for the spot rate than under the hypothesis of normality.

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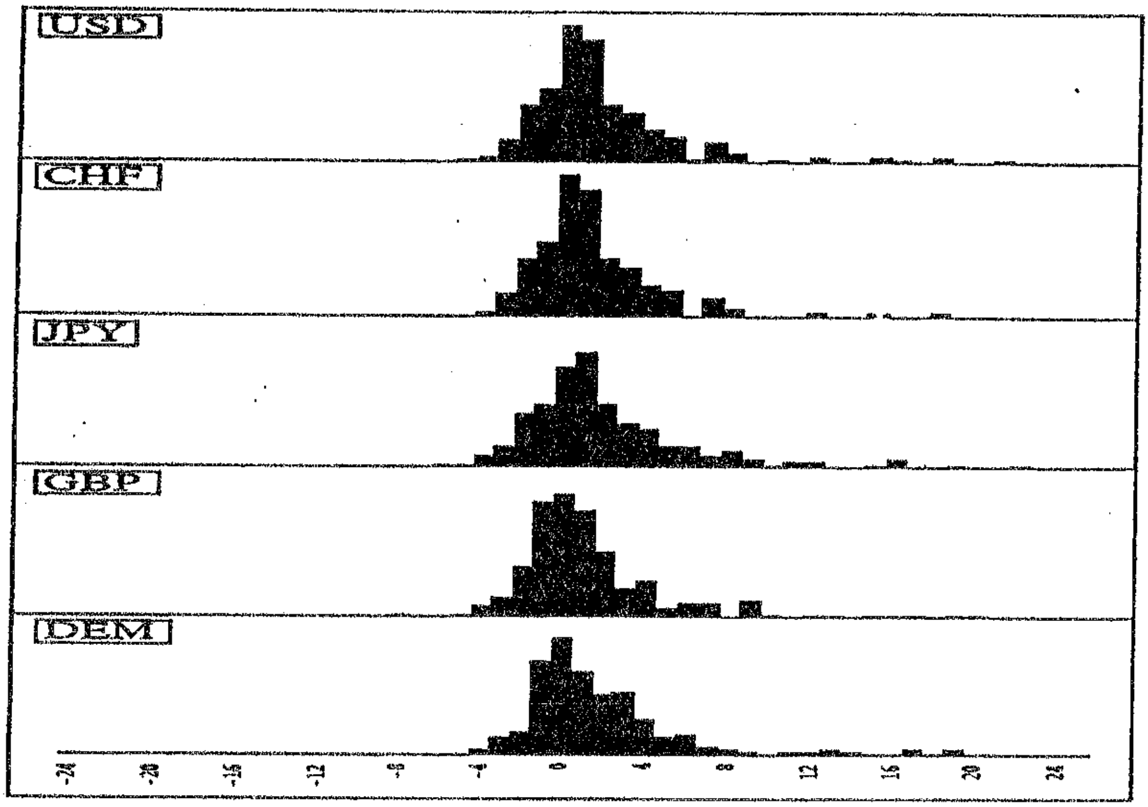
[6]See de Vries (1993) for a discussion.

Figure 4.11. Monthly changes in the price of the ISK; 1974-1992

Percentages per month



4.2.2. Historical Patterns in the Real Exchange Rate

Finally, we look at the development of the real exchange rate. The real exchange rate is defined in equation (2.22). The change in the log of the real exchange rate can therefore be written as:

$$(4.2) \quad \Delta\lambda_t = \Delta s_t - (\Delta p_t - \Delta p_t^*).$$

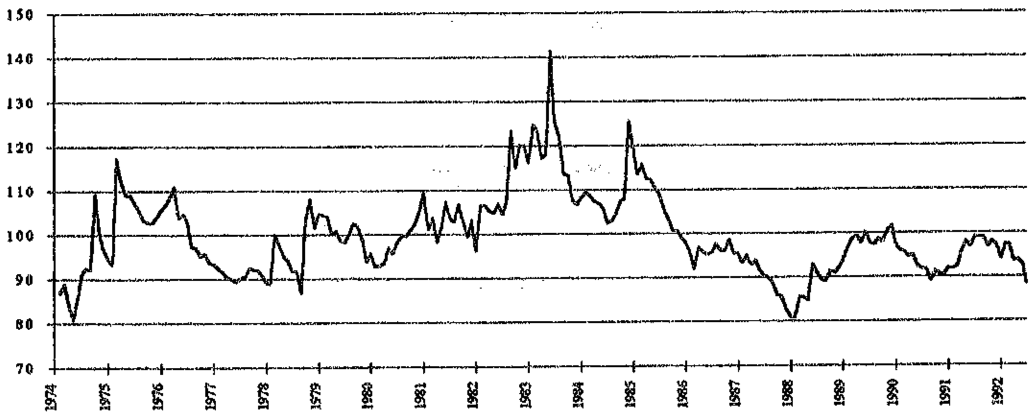
Thus, given the nominal exchange rate, higher domestic inflation than foreign inflation (a fall in domestic competitiveness) is indicated by a fall in Λ_t, or a rise in the real exchange rate. If domestic inflation is continuously higher than foreign inflation, the nominal exchange rate has to be continuously devalued, if domestic competitiveness is to be kept intact. These deviations from PPP also indicate wether the domestic currency is over- or undervalued. For an index with a parity value of 100, values over 100 will indicate an undervalued currency and values under 100 will indicate that the domestic currency is overvalued.

The development of the real exchange rate can be seen in figure 4.12. There it can be seen, that over the whole period 1974 to 1992 the real exchange rate has not changed very much. It has for most of the period been under parity, indicating a high real exchange rate. This tells us that even though the domestic currency has continuously been devalued, so as to lower the real exchange rate, the difference in domestic and foreign inflation has been so high that the real exchange rate has remained above equilibrium. The Icelandic krona has, therefore, been overvalued for most of the period, having serious effects on domestic competitiveness.[7]

Within our sample period, however, the real exchange rate has been very volatile, reaching its lowest point between 1983 and 1984. In the years 1974, 1978 and 1988 the real exchange was very high.

Figure 4.12. The development of the real exchange rate; 1974-1992

Real effective exchange rate, monthly data, index = 100 1979



This development can be seen further in table 4.5, which shows the mean and the standard deviation in the real exchange rate. There we see that on average the real exchange rate has been over parity. Looking at the subperiods it also seems that the real exchange rate has been increasing. Looking at the standard deviations in the real exchange rate, we also see that the real exchange rate has been quite volatile, although this volatility is much less in the last subperiod, 1990 to 1992.

[7]See, for example, the discussion in Magnússon (1992).

Table 4.6. Mean and standard deviation of the real exchange rate; 1974-1992:6

Percentage changes, monthly data

Series	Obs	Mean	Std Error	Minimum	Maximum
1974 - 1992:6	222	93.19577701	8.455060926	75.82535427	131.2780338
1974 - 1983	120	95.41863892	9.001314708	75.82535427	131.2780338
1984 - 1989	72	91.46952861	7.916973188	76.00190781	116.0317845
1990 - 1992:6	30	88.44732551	2.772712826	82.98413549	92.60309651

Finally, we note that the deviations of the real exchange rate are deviations from the PPP condition. This indicates large short run deviations from the PPP relationship, which implies that the PPP condition cannot be expected to hold at every moment. We are not able, however, to reject the PPP relationship as a long run equilibrium condition. Therefore, the possibility of total financial integration is still open. This will be analysed in detail in chapter six.

These large fluctuations in the real exchange rate also indicate that a risk premium for exchange rate risk might play a role in our analysis. This premium is discussed in the next chapter, along with the premium for political risk.

5. Domestic Links with International Markets

In this chapter we analyse the deviations from the financial relations described in chapter two. Accordingly, we analyse deviations from the UIP relationship, which is our basic motivation for including risk premiums. We find that there have been substantial short run deviations from the UIP relation. Finally, we develop our proxies for exchange rate risk and political risk, respectively.

5.1. Short Run Deviations from Uncovered Interest Rate Parity

Our basic model for analysing financial integration is the UIP condition. This condition states that if the domestic and foreign financial markets are directly integrated, the expected return should be the same on both markets, i.e. the law of one price for financial securities should hold (see equation 2.7). As mentioned before, the UIP condition assumes risk neutrality on the behalf of financial investors. Therefore, they do not demand premiums for exchange rate and political risk, respectively.

Finding significant short run deviations from the UIP relation indicates that we need to take account of political and exchange rate risk and transactional costs before we can conclude anything concerning financial integration. If the risk premiums and transaction costs are stationary processes (it is very likely that the transaction cost is very stable) we only need to analyse the risk neutral version of the UIP to draw any conclusions on the long run validity of the UIP relationship.

There is one problem, however. As discussed in chapter two, actual data on expectations are not available, so we have to make some assumption concerning expectations formation. We use the rational expectations hypothesis, which links expectations to actual data according to equation (2.15).

Taking equation (2.15) and the UIP condition in equation (2.8), we can write the UIP condition as:

$$(5.1) \quad \left(\frac{r_t - r_t^*}{1 + r_t^*}\right) = \dot{S}_t - \frac{\varepsilon_{t+1}}{S_t},$$

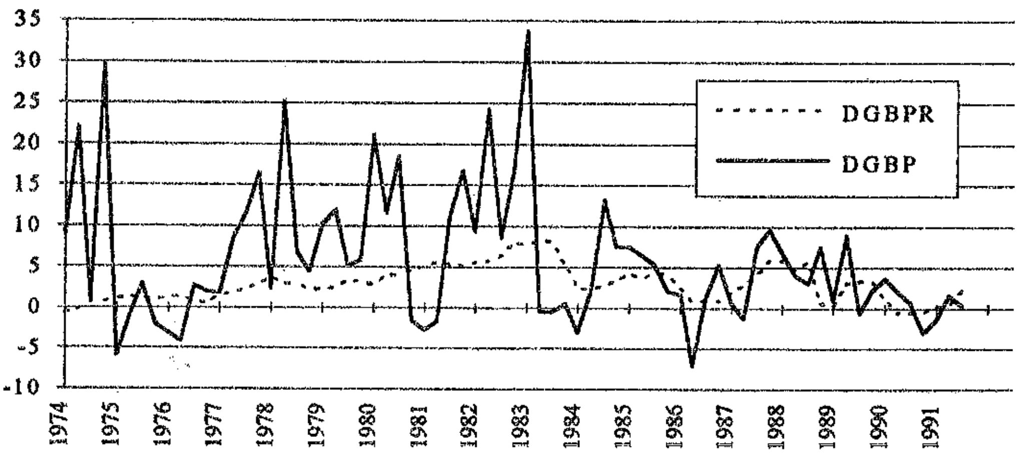
where ε_{t+1} is the forecast error. Here we take the simplified view of the rational expectations hypothesis, namely the perfect forecast hypothesis, which assumes that ε_{t+1} equals zero. This assumption is frequently made in the international financial literature. This allows us to use *ex post* data as a proxy for *ex ante* expectations. This implies that we can analyse the deviations from the UIP condition as:

$$(5.2) \quad \Phi_t = \frac{(r_t - r_t^*)}{(1 + r_t^*)} - \dot{S}_t.$$

The problem with the interpretation of these results is that, as discussed in chapter two, we have reasons to believe that the forecast errors may deviate from zero, without indicating market inefficiency, due to the Peso problem. This must be kept in mind when interpreting our findings below and makes any interpretation of financial integration on the basis of *ex post* data difficult.

In figure 5.1 we plot the interest rate differential between Icelandic and British three month prime rates and the exchange rate movement of the ISK/GBP rate. We see that the interest rate difference is positive for the whole period, indicating that domestic interest rates have remained higher than in the U.K. We also see that the expected exchange rate has also been positive for most of the period, indicating expected depreciation, and that it is very volatile, especially before 1984.

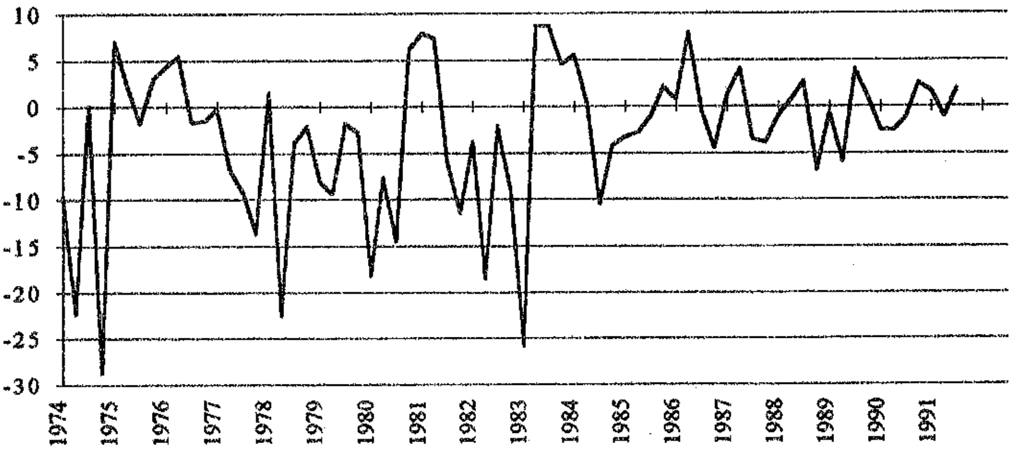
Figure 5.1. The Uncovered interest rate parity for ISK/GBP; 1974:I-1991:III
Quarterly observations, annual percentages



For the UIP condition to hold the difference between the interest rate differential and the expected depreciation should be zero. Looking at the figure, it is quite obvious that this is not true. This can also be seen in figure 5.2, which reports the short run deviations from UIP, Φ_t in equation 5.2.

Figure 5.2. Deviations from UIP for ISK/GBP; 1974:I-1992:III

Quarterly observations, annual percentages



Here we see that these short run deviations have often been quite substantial, indicating the failure of the basic UIP relationship between Iceland and the U.K to hold in all periods. This could indicate the existence of a demand for risk premiums covering political and exchange rate risk. The deviations are also volatile, due to the fluctuations in the expected exchange rate.

We also see that Φ_t is negative for most of the period. This indicates that capital controls, implied by $\Phi_t \neq 0$, are mainly operating to prevent capital from flowing *out* of the domestic country. This is because a negative Φ_t means that the return on domestic investments, $(1+r_t)$, is lower than the expected return on foreign investments, $(1+r_t^*)(1+E_t\dot{S}_t)$.[1] Investors would therefore not settle for a lower return on domestic investments, if they where free to invest abroad for a higher expected return.

What is of most interest, however, is that figures 5.1 and 5.2 indicate that the short run deviations from UIP have decreased substantially since 1984. This is, of course, what one should expect, taking account of the structural change in interest rate determination in Iceland at that time and the beginning of removing capital controls. This could also indicate the reduction in the demand for both political and exchange rate risk due to these institutional changes.

This also draws attention to an argument made by Oxelheim (1993). He argues that restrictions on capital movements were removed *de facto* much earlier than *de jure*. That is, competitive forces often seem to contribute towards completion of actual liberalisation, which is only afterwards confirmed by formal deregulation. The structural change in the short run deviations in the UIP relation in Iceland in 1984,

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[1]The only uncertainty here is because of uncertain movements in the exchange rate.

could be interpreted as such a phenomenon. The largest firms had already gained access to foreign capital much earlier than formal liberalisation took place, which in turn had effects on the domestic short run interest rate dynamics.

Figures 5.3 - 5.8 tell a similar story, for the UIP relation between Iceland, on one hand, and Germany, Japan and the U.S., on the other. In all cases have interest rates remained higher in Iceland for the whole period. There have also been high and volatile expected devaluations of the krona against all these currencies.

Again there are substantial and frequent short run deviations from UIP, for all these currencies, which have, however, decreased after 1984.

Figure 5.3. The Uncovered interest rate parity for ISK/DEM; 1974:I-1992:III

Quarterly observations, annual percentages

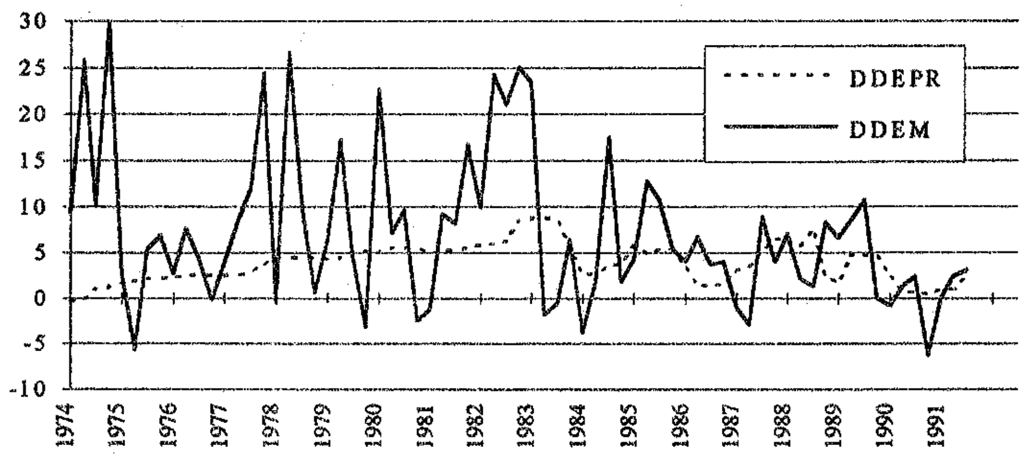


Figure 5.4. Deviations from UIP for ISK/DEM; 1974:I-1992:III

Quarterly observations, annual percentages

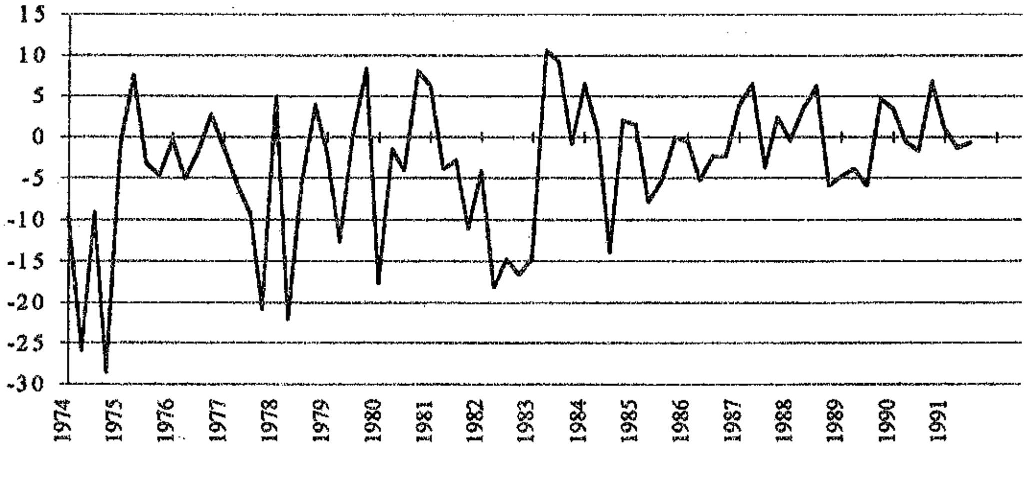


Figure 5.5. The Uncovered interest rate parity for ISK/JPY; 1974:I-1992:III

Quarterly observations, annual percentages

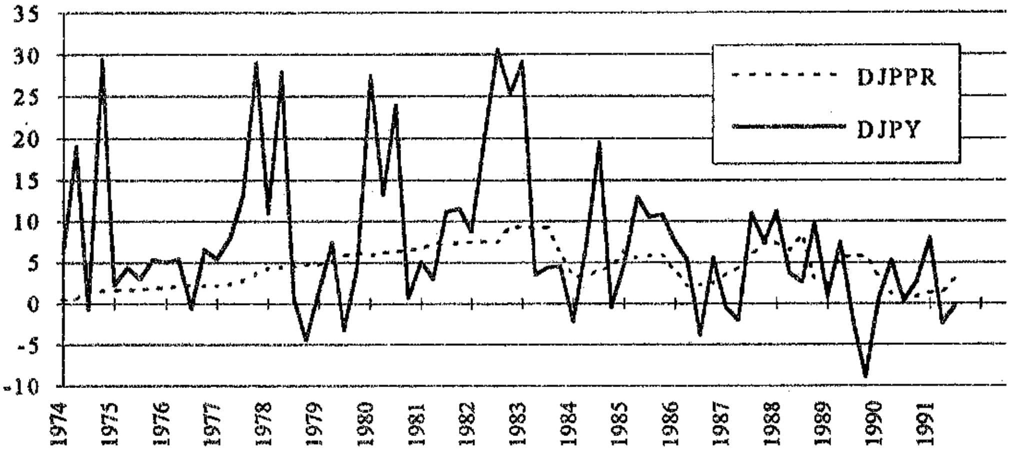


Figure 5.6. Deviations from UIP for ISK/JPY; 1974:I-1992:III

Quarterly observations, annual percentages

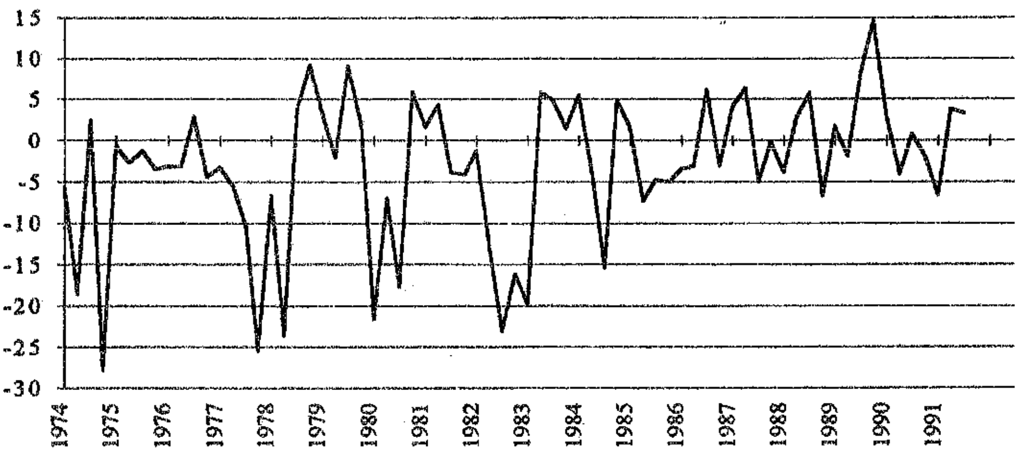


Figure 5.7. The Uncovered interest rate parity for ISK/USD; 1974:I-1992:III

Quarterly observations, annual percentages

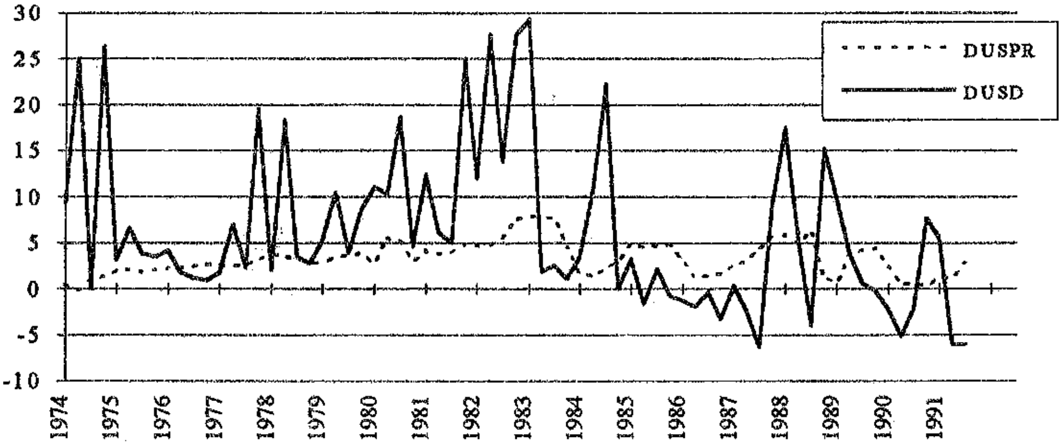
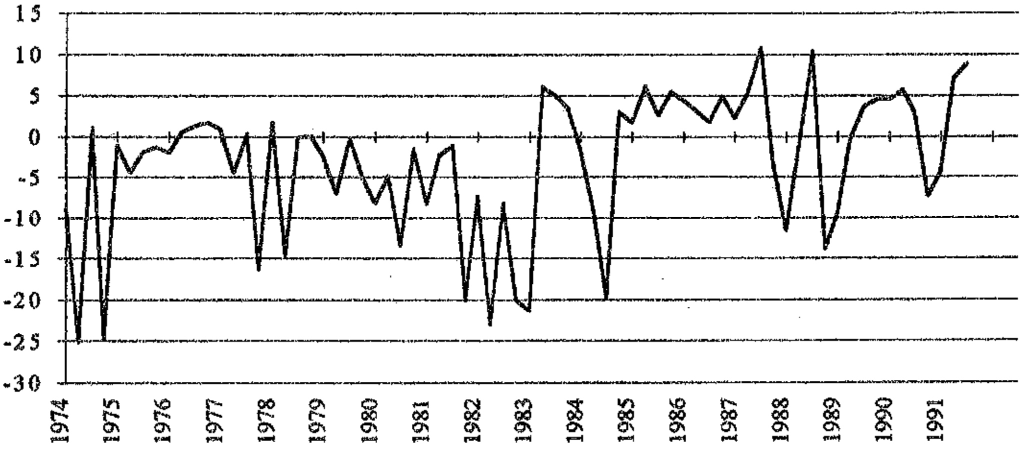


Figure 5.8. Deviations from UIP for ISK/USD; 1974:I-1992:III

Quarterly observations, annual percentages



The deviations from UIP are also negative for most of the period, which, again, indicates that capital controls have mainly existed to prevent capital from flowing out of the country.

Finally, this development can be seen further in table 5.1, which shows the mean and the standard deviations of Φ_t.

Table 5.1. Mean and standard deviations of the deviations from UIP; 1974:I-1991:III *Quarterly observations, annual percentages*

1974 - 1991:III

Series	Obs	Mean	Std Error	Minimum	Maximum
UIPUS	71	-3.096253649 *	8.635951501	-25.15625	10.80170829
UIPDE	71	-3.314702275 *	8.350160932	-28.52343495	10.60457118
UIPGB	71	-3.029108093	8.051402856	-28.76684322	8.654868119
UIPJP	71	-3.146247684 *	8.848084163	-27.77666062	14.62013679

1974 - 1983

Series	Obs	Mean	Std Error	Minimum	Maximum
UIPUS	48	-5.201141325	8.705421952	-25.15625	6.098672689
UIPDE	48	-4.869864625	9.408923162	-28.52343495	10.60457118
UIPGB	48	-4.375434545	9.23208751	-28.76684322	8.654868119
UIPJP	48	-5.073635685	9.582223008	-27.77666062	9.188125278

1984 - 1991:III

Series	Obs	Mean	Std Error	Minimum	Maximum
UIPUS	23	1.296555415 **	6.749472647	-13.87700179	10.80170829
UIPDE	23	-0.069146067 **	4.054132786	-5.942488537	6.736641231
UIPGB	23	-0.219383322 **	3.459500783	-6.77661352	7.973376948
UIPJP	23	0.876127276 **	5.28406075	-6.65908991	14.62013679

* The hypothesis that the mean is zero is not rejected using 1 percent significance level.
** The hypothesis that the mean is zero is not rejected using 5 percent significance level.

For the period as a whole there seems to be only significant short run deviations in the ISK/GBP rate.[2] When we look at the subperiod 1974 to 1983 there are however significant deviations in all of the rates. Our observation that the short run deviations from UIP have decreased substantially since 1984 is also evident when we look at the second subperiod. There we see that significant deviations from UIP are not found for any of the four exchange rates. This should give some indication for that financial integration has increased in Iceland, although further investigation of that hypothesis is relegated to the next part of our study where we study the long run behaviour of the UIP relationship. It is also obvious when looking at the standard deviations of Φ_t that the volatility of the deviations have decreased substantially since 1984.

To summarise, nominal interest rates have been higher in Iceland than in the other countries in our comparison. There have, however, been high expectations of a depreciation of the krona, which have resulted in higher expected return for foreign investments. Capital has been prevented from moving abroad by capital controls. Taken together, this results in large and frequent short run deviations from the UIP

[2]The mean of the deviations from UIP where found using an ARMA model, so as to avoid any problems of serial correlations in the series, when testing the hypothesis of whether the deviations are statistically significant from zero. In his study, Oxelheim (1993) uses non-overlapping data.

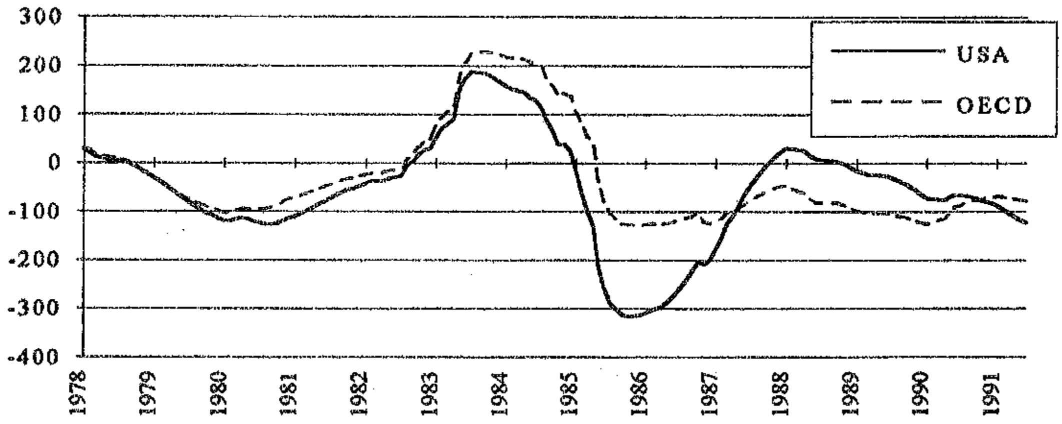
condition for the Icelandic krona. These short run deviations seem, however, to have decreased substantially in 1984, indicating increased financial integration in Iceland in the short run. These results should, however, be interpreted with caution since we have not analysed the long run behaviour of the UIP in a formal way. This has to be done for us to be able to make any inference on long run financial integration in Iceland, that is whether the UIP condition is a long run equilibrium condition. This is done in the final part of our study.

5.2. Exchange Rate Risk

Up to now we have assumed risk neutrality on the behalf of investors. As discussed in chapter two, we also want to allow for the possibility that investors demand premiums for both exchange rate risk and political risk. These premiums for the Icelandic krona are analysed in this and the next chapter.

Our measure for the exchange rate risk was given in equation (2.26) in chapter two. This proxy measures the exchange rate risk of the Icelandic krona as the relative volatility of the real exchange rate for the Icelandic and the respective foreign currency. We use two calculations for the foreign currency, the U.S. dollar and the global rate, respectively. The results can be seen in figure 5.9.[3]

Figure 5.9. Relative exchange rate risk attached to the ISK; 1977:12-1991:6
Monthly data



In figure 5.9 we can see that the volatility of the deviations from PPP for the krona was greater than for the corresponding foreign rates in 1978 to 1979, 1983 to 1985 and 1988 to 1989. In other periods the volatility was less for the krona. This seems to indicate that the relative risk of the krona has been less than that of the U.S. dollar and

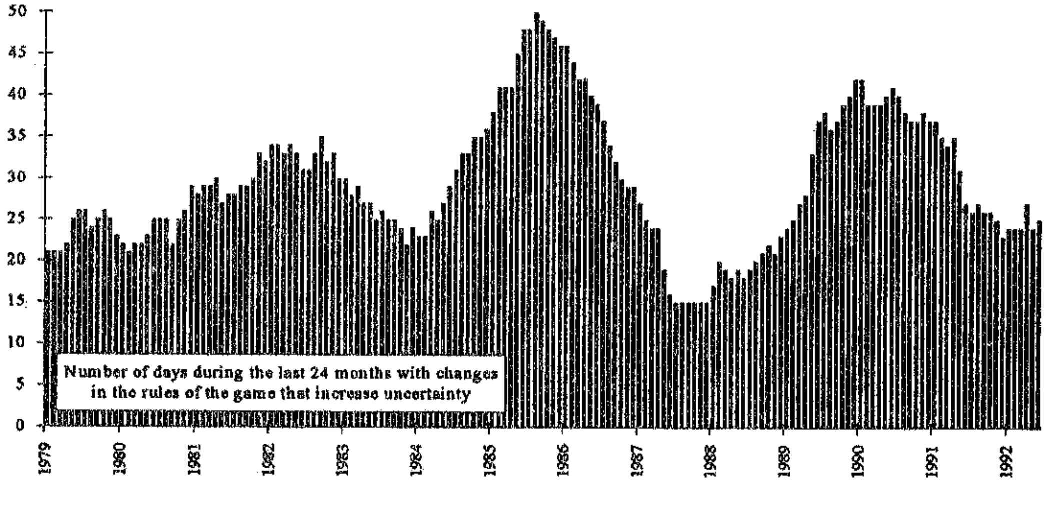
[3]See appendix one.

the global rate, measured as the trade weighted average of the U.S. dollar, Japanese yen and German mark for number of years in the period of our study. This result is in line with the findings of Oxelheim (1993) for the other Nordic currencies. The reasons for this perhaps surprising result are perhaps many, but one of them could be the often substantial volatility of the dollar and the fact that the krona has not been on the market and has therefore never been subject to speculative attacks. Another reason is that the USD and JPY have been floating for the whole period, whereas the ISK has been kept fixed for most of the period.

5.3. Political Risk

We suggest two proxies for measuring the political risk premium. The first one is to measure the political risk as a frequency of changes in the rules of the marketplace. That is, international investors demand a risk premium for unexpected changes in regulations that can affect the return of their investments. In this case we assume that these investors base their behaviour on their past experience. As mentioned in chapter two, this measure can capture the part of the political risk premium that is related to the reputation of the policy maker as an interventionist. This premium is calculated as the number of days rules concerning the financial market have been changed (deregulations excluded) during the last 24 months. This proxy can be seen in figure 5.10.[4]

Figure 5.10. Political risk in Iceland; 1979:1-1992:6
Monthly data



[4]The data is available from the authors on request.

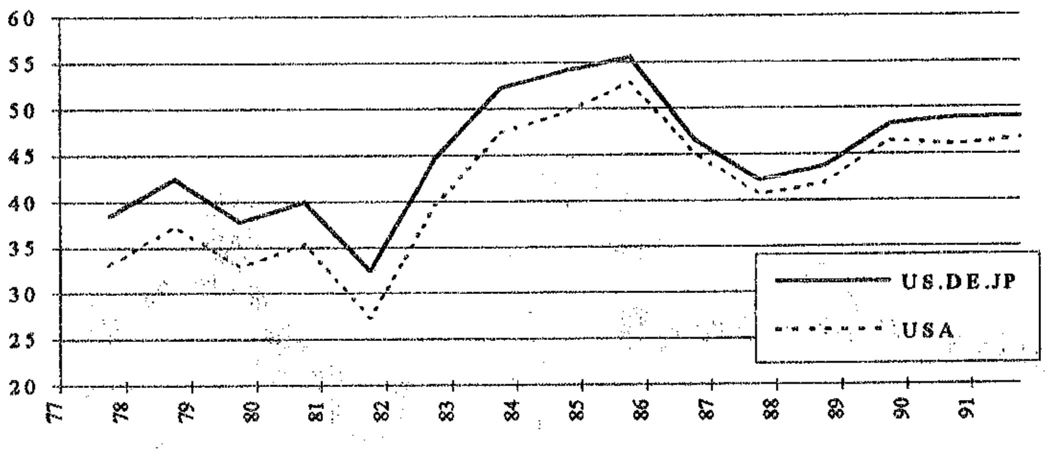
Figure 5.10 indicates that political instability related to the financial market reached its peak in the period mid 1983 to mid 1985. In that period a number of changes occurred, such as large deprecations of the krona, changes in interest rates, changes in indexation, changes in tax laws, changes in rules concerning foreign currency holdings, changes in banking reserves regulations, and so forth. This resulted in a peak in the demand for a risk premium in mid 1986, since this part of the political risk premium is calculated using the last 24 month history.

The other part of the political risk is measured by the net relative indebtedness of a country. In this case, foreign investors will see increasing indebtedness as indicating higher probabilities of domestic policy interventions sometime in the future, and will therefore demand a premium to cover themselves from that particular risk. As mentioned in chapter two, this part is meant to capture the future risk of political interventions.

In figure 5.11 we show the net foreign debt as a percentage of GDP of Iceland in relation to the U.S. and "global" indebtedness.

Figure 5.11. Iceland's foreign indebtedness in relation to U.S. and global foreign indebtedness; 1974-1991

Quarterly data, Net foreign debt as a percentage of GDP



We use the relative indebtedness to convert these into risk variables. In the figure we can see that the difference between Iceland's indebtedness and the U.S indebtedness, relative to GDP, has grown from being 25 percent to nearly 40 percent over the period. Through the sample period the difference has fluctuated somewhat, and reached its peak in the period 1985 to 1986, which indicates that the probability of domestic policy interventions reached its peak in that period. Interestingly enough, this is the same result as the first proxy for political risk gives. This could, however, indicate multicollinearity problems when the proxies are used together.

Part IV. A Model of Financial Integration in Iceland

In this part of our study we introduce the methodology we intend to use for analysing long run relationships between interest rates and prices in Iceland and the rest of the world. This enables us to make statistical inference concerning financial integration in Iceland. In chapter six we describe the methodology and analyse the time series properties of our series and chapter seven contains the model and its estimation.

6. Cointegration Theory

6.1. Univariate Cointegration

There is no doubt that the development of cointegration theory has been one of the most important developments in econometric theory since the seminal paper of Engle and Granger (1987).[1]

The main idea behind cointegration, and what is most appealing with this method, is that it can reveal the existence of long run equilibrium relationships between two or more economic variables. This is very interesting for economists since most of economic theory is concerned with relationships that hold in the long run but has much less to say about short run behaviour of economic variables. The main advantage of cointegration theory is that it helps detecting these long run relationships that are generally obscured by short run deviations from equilibrium.[2]

Testing for long run relationships with standard classical regression theory would be possible if the variables in question were stationary. The problem is however that most economic variables are non-stationary and using classical regression theory on non-stationary processes would give rise to spurious regressions.[3] Previously, the standard way to deal with non-stationarity was to take time difference until the series where stationary, but this involves a serious drawback as time differences result in a complete loss of all long run information in the data.

Using cointegration, allows short run deviations away from the hypothesised long run equilibrium. However, for this to hold as a long run equilibrium these deviations must remain bounded over time, otherwise the variables will tend to diverge without bound and it will be hard to justify that any long run relationship existed. It is

[1]The idea had been introduced as early as 1984 in seminars and conferences.

[2]In this context, equilibrium is defined as a stationary process that is characterised by forces which tend to push the economy back toward this point whenever it moves away. See Engle and Granger (1987).

[3]That is, we could accept the hypothesis of a long run equilibrium even though there was no such relation at all.

therefore obvious that testing whether the deviations from the long run equilibrium are stationary (exhibit mean reversion) will give us necessary and sufficient conditions for a long run equilibrium.

The formal definition of cointegration is as follows. If we have a series, y_t, it is said to be integrated of order d, denoted as $y_t \sim I(d)$, if it has a stationary, invertible, non-deterministic ARMA representation after differencing d times.[4] A necessary condition (but not sufficient) for a pair of series to be cointegrated is that they be integrated of the same order.[5] That is, if we have another series, x_t, both y_t and x_t must be $I(d)$ for them to be possible to cointegrate.

In most cases a linear combination of $I(d)$ series:

$$(6.1) \quad w_t = y_t - \beta x_t,$$

will also be $I(d)$. However, in some cases there may exists a constant β in equation (6.1) such that $w_t \sim I(d\text{-}b)$, $b>0$. In these cases y_t and x_t are said to be cointegrated of order b, denoted as $(y_t, x_t)' \sim CI(d,b)$.[6] The vector $(1,-\beta)$ is called the cointegrating vector and $(y_t, x_t)'$ the cointegrated set. This implies that it is possible to combine two or more non-stationary series in a linear combination in a single regression, without creating the spurious regression problem since this linear combination is stationary.

Equation (6.1) can be rewritten as:

$$(6.2) \quad y_t = \beta x_t + w_t.$$

which implies a long run relationship between y_t and x_t if they are cointegrated. It is important to note that this long run relationship need not be satisfied at each point of time. There can be short run deviations from this long run equilibrium. These deviations are however bounded when cointegration holds.

Engle and Granger (1987) provided a theoretical basis for the analysis of the short run dynamics which takes into account the long run equilibrium implied by cointegration. They proved that when x_t and y_t are cointegrated, there always exists an *Error Correction* (ECM) representation of the short run behaviour (6.2):[7]

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[4]Thus, an $I(0)$ series is itself stationary, whilst the simplest example of an $I(1)$ series is a random walk.

[5]This only holds when we have two series. If there are three or more series involved, it is possible for them to cointegrate even though they are integrated of different order.

[6]For instance, if x_t and y_t are $I(1)$ and if they cointegrate, w_t will be $I(0)$. That is, even though x_t and y_t may each have infinite variance, the linear combination w_t is stationary. This would suggest a stable long run relationship between x_t and y_t.

[7]Further, Nickell (1985) has proved that the ECM representation can be derived as an optimal decision rule for an infinite horizon quadratic optimisation problem.

$$(6.3) \quad \Delta y_t = a + \alpha(y_{t-1} - \beta x_{t-1}) + \sum_{i=1}^{k} \gamma_i \Delta x_{t-i} + \sum_{i=1}^{k} \theta_i \Delta y_{t-i} + \varepsilon_t .$$

This is a statistical model containing only stationary variables, if y_t and x_t are $I(1)$, with an error term with a well-defined first and second moment. Standard classical regression theory is therefore easily applied to this model. The ECM representation relates the present change in y_t to the past deviations of y_t from its long term path $(y_{t-1} - \beta x_{t-1})$, to the present change in x_t and to the past changes in y_t and x_t.[8] In the literature, α is referred to as the error correction parameter and $(y_{t-1} - \beta x_{t-1})$ as the error correction term (which is identical to w_t). The speed of adjustment of y_t to its long run equilibrium is determined by α. For the ECM representation to be stable α must be negative and less than one in absolute value.

In this study we want to test two cointegration hypotheses. First we have that the Icelandic and global goods markets are cointegrated. Taking the logarithmic version of the PPP relation (equation 2.2) and allowing for short run deviations from this relationship we get the following:

$$(6.4) \quad \lambda_t = s_t + p_t^* - p_t,$$

where λ_t is the log of the real exchange rate and represents short run deviations from PPP. For PPP to hold as a long run relationship we must therefore have that the real exchange rate is an $I(0)$ series.[9] Here, the cointegrating vector would be (1,1,-1) and the cointegrated set $(s_t, p_t^*, p_t)'$. Finding that the real exchange rate is a stationary process and that the cointegrated vector (1,1,-1) cannot be statistically rejected, would indicate that the domestic and foreign goods markets were perfectly integrated in an economic sense.[10]

The other hypothesis we want to test is that the Icelandic and global financial markets are cointegrated. Taking logarithmics of equation (5.2) we get:[11]

$$(6.5) \quad \phi_t = (r_t - r_t^*) - E_t \Delta s_t,$$

[8]The ECM representation was first introduced in econometrics by Sargan (1964).

[9]In chapter 6.3 we find that the exchange rate, domestic and foreign prices and domestic and foreign interest rates are all $I(1)$.

[10]It should be noted that using the relative version of PPP rather than the absolute version would give identical results, namely that the real exchange rate has to be $I(0)$ for PPP to be a long run equilibrium. See Taylor and McMahon (1988).

[11]We relegate the discussion on the risk premiums until the next chapter.

where $\phi_t \equiv \ln \Phi_t$ represents short run deviations from UIP. For UIP to hold as a long run relationship we must therefore have that these deviations are stationary. Notice that since s_t is $I(1)$, as we will see later, we have that $E_t \Delta s_t$ is stationary. This indicates that for the UIP to hold as a long run relationship, it must be that domestic and foreign interest rates cointegrate. It follows therefore that the cointegrating vector would be (1,-1) and the cointegrated set $(r_t, r_t^*)'$. Finding that the deviations from UIP are stationary and that the cointegrating vector (1,-1) cannot be statistically rejected, would indicate that the domestic and foreign goods markets were perfectly integrated.

If the deviations from PPP and UIP are both stationary and the cointegrating vectors are (1,1,-1) and (1,-1) respectively, we have perfect total financial integration, by the terminology of chapter one. If only the UIP relation holds in the long run, we have perfect direct financial integration. If there are risk premiums involved the financial integration will be less than perfect.

Testing the PPP and UIP theories by using the cointegration methodology of Engle and Granger (1987) only allows us to test for one cointegrating relationship in each case. However since the cointegrating set for the PPP relationship contains three variables there can possibly exist two long run relationships in the PPP. It should therefore be preferable to use a method that allows for more than one cointegrating relationship. Further, when testing the PPP and UIP relationships separately we will lose information on the interdependency between them. The exchange rate, for example, is both affected by the goods and the asset markets. It would therefore be preferable to test these relationships together. This is discussed in the next section.

6.2. Multivariate Cointegration: The Johansen Methodology

When we have multivariate time series the possibility of more than one cointegrating vector arises. In this case a method that takes account of this possibility is preferable to the bivariate case of Engle and Granger (1987) which assumes only one cointegrating vector. It is simple to show that if we have a $(N \times 1)$ vector, $X_t = (x_{1t}, \ldots, x_{Nt})'$, there can exist as many as N-1 cointegrating vectors. The Johansen method is based on estimating the group of cointegrating vectors in a VAR process by maximum likelihood estimation techniques.

This approach, developed by Johansen (1988, 1991) and Johansen and Juselius (1992), has several advantages over the two step regression method suggested by Engle and Granger (1987) and the three step regression method suggested by Engle and Yoo (1987). First, by using a full system of equations it is possible to allow for interactions in the determinations of all the endogenous variables, which is likely to reduce the variance of the residuals substantially compared to analysing each equation separately. Second, the model specification explicitly allows for different short run and long run dynamics in the data. This distinction is very important in an analysis of financial integration, since we are dealing with two types of markets; a goods market where the adjustment process is slow and costly and a financial market where the adjustment process is much faster and arbitrage much easier. Third, the Johansen method relaxes the assumption that the cointegrating vector is unique. It provides statistical estimates of all the cointegrating vectors and test statistics for their number. Finally, it is possible to test different structural hypothesis concerning the estimated parameters.

Formally, the Johansen estimation technique is based on the ECM representation of a vector autoregressive (VAR) model with Gaussian errors:

$$(6.6) \quad \Delta X_t = a + \sum_{i=1}^{k-1} \Gamma_i \Delta X_{t-i} + \Pi X_{t-k} + \xi_t; \qquad t = 1,\ldots,T,$$

where X_t is a $(N\times 1)$ vector of $I(1)$ variables, a is a constant, $\Gamma_1,\ldots,\Gamma_{k-1},\Pi$ are $(N\times N)$ matrices of unknown parameters and $\xi_t \sim N(0,\Sigma)$. Note that there is no loss of long run information, as is usual when differenced data is used, all the long run information is contained in the levels component ΠX_{t-k}. Since X_t is $I(1)$ and ξ_t is stationary it follows that Π cannot have full rank, since this would indicate inconsistent interpretation of the model.[12] If Π=0 the model would be statistically consistent but would contain no long run information in the data and (6.6) would reduce to a standard VAR model in first differences. If Π is different from zero, its rank would have to be less than N, say q, called the cointegrating rank. The model thus implies the existence of q linear cointegration vectors, each defining a long run relation in the data.

By regressing ΔX_t and X_{t-k} on a constant and $\Delta X_{t-1},\ldots,\Delta X_{t-k+1}$ we get the estimated residuals, $\hat{\xi}_{1t}$ and $\hat{\xi}_{2t}$, respectively. From this we can define the product moment matrices of these residuals as $A_{ij} \equiv T^{-1}\sum_{t=1}^{T} \hat{\xi}_{it}\hat{\xi}_{jt}$, $i, j = 1, 2$.

The Johansen procedure estimates (6.6) subject to the hypothesis that Π has a reduced rank, $q < N$. This hypothesis can be written as:

$$(6.7) \quad H_1(q): \Pi = \alpha\beta',$$

where α is a $(N\times q)$ matrix of the error-correction coefficients and β is a $(N\times q)$ matrix of the cointegrating vectors. Under certain conditions this reduced rank condition

[12]See, for example, Juselius (1991).

implies that the process ΔX_t is stationary, X_t is non-stationary and that βX_t is stationary. The stationary relations βX_t is referred to as the cointegration relations.[13]

The maximum likelihood estimation of the cointegrating vector, β, can be found by solving the eigenvalue problem:

$$(6.8) \quad \left|\varphi A_{22} - A_{21}A_{11}^{-1}A_{12}\right| = 0.$$

This eigenvalue problem has the solutions $\hat{\varphi}_1 > ... > \hat{\varphi}_N > 0$ with the corresponding eigenvectors $\hat{V} = (\hat{v}_1, ..., \hat{v}_N)$ normalised by $\hat{V}' A_{22} \hat{V} = I$.[14] The maximum likelihood estimator for β is thus:

$$(6.9) \quad \hat{\beta} = (\hat{v}_1, ..., \hat{v}_q),$$

which gives the maximum likelihood estimation of α as:

$$(6.10) \quad \hat{\alpha} = A_{12}\hat{\beta}.$$

Phillips (1991) has shown that the maximum likelihood estimator is super-consistent, symmetrically distributed and median unbiased asymptotically. Cheung and Lai (1993) also find that the Johansen method has substantial power advantage over the standard residual-based tests used in the Engle-Granger, bivariate cointegration methodology.

When q is unknown it must be estimated. Two alternative test statistics have been proposed, both which can be used to find the maximum number of cointegrating vectors. Both are likelihood ratio tests. The first test statistic, called the maximum eigenvalue test ($\hat{\varphi}_{MAX}$) statistic, assumes under the null hypothesis that the number of cointegrating vectors is $q = \overline{q} \leq N$. The null hypothesis is compared to the alternative hypothesis of $q = \overline{q} + 1$ using the following test:

$$(6.11) \quad -2\ln Q = -T\ln(1 - \hat{\varphi}_{q+1}).$$

The second test statistic, called the trace test ($\hat{\varphi}_{TRACE}$) statistic, uses the same null hypothesis against the maintained hypothesis of $q \geq \overline{q} + 1$. The following test statistic is used:[15]

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[13]See Johansen (1988) and Johansen and Juselius (1992).

[14]For further details, see Johansen (1988) and Johansen (1991:*a*).

[15]There is no obvious rule for which of the test statistics to choose. The trace statistic will usually have more power when several eigenvalues are close to being significant, whereas the maximum eigenvalue test statistic has more power when the estimated eigenvalue is either large or close to zero. Consequently the maximum eigenvalue statistic is usually preferable when the estamtes

$$(6.12)\quad -2\ln Q = -T\sum_{i=\hat{q}+1}^{N}\ln(1-\hat{\varphi}_i).$$

By using these test statistics it is possible to assess the presence of a maximum of q cointegration relationships, against the alternative hypothesis of non-existence of any of them. Consequently it can be tested which vector corresponds to the existing long run relationships. This method is based on the number of possible stationary linear combinations among trend variables, which gives support to the fact that these series have one or several common trends.[16] The mathematical derivation of these results is described in more detail in Johansen (1988). Tables for statistical inference are found in Johansen and Juselius (1990).

Once we have determined the number of cointegrating vectors, it is possible to test several interesting structural hypotheses.[17] The first is to test the hypothesis that there exist some variables in the cointegrating space that are weakly exogenous. Here, the hypothesis to test is:

$$(6.13)\quad H_2 : \alpha_{ij} = 0; j = 1,\ldots,q.$$

The intuition behind this is that if some element of the matrix α , $\alpha_i = 0$, then ΔX_t is weakly exogenous for α and β in the sense that the conditional distribution of ΔX_t, given ΔX_t and the lagged values of X_t, contains the parameters of α and β, whereas the distribution of ΔX_t given the lagged X_t does not. If the hypothesis in (6.13) can be accepted we can reduce the system by one dimension without affecting the estimates of β. The other type of hypothesis are structural linear hypothesis on the cointegrating relations. These hypotheses are structural in the sense that they do not depend on any normalisation of β.[18]

Using the Johansen methodology allows us to test the PPP and UIP relations jointly which is important since, as Johansen and Juselius (1992) note, these relations are related to markets that are quite different in nature. As mentioned before, the adjustment speed in the goods market is probably slow, while the adjustment speed in the asset market is probably very fast. We are able to analyse the interactions between exchange rates, interest rates and prices in the goods and asset markets in a

discriminate effectively between small and large eigenvalues, while the trace statistic is usually preferable when the estimated eigenvalues are evenly distributed. See Juselius (1991).

[16]See Camarero and Tamarit (1993).

[17]See Johansen and Juselius (1990 and 1992).

[18]For further discussion on these hypotheses, see Johansen and Juselius (1990 and 1992) and Camarero and Tamarit (1993). For a derivation of the test statistics, see for example Johansen and Juselius (1992) and Johansen (1991:a).

simultaneous model, explicitly analyse the short run behaviour of these variables and how they tend to jointly compensate the deviations from PPP and UIP and support a long run equilibrium. For example, the interest rate differential may be interpreted as an explanatory factor of the adjustment process for prices coming from the financial market.

Our model does not make any assumption concerning the specific form of short run dynamics. However, the PPP and UIP relations determine the long run steady state solution. The interesting long run relations are therefore the PPP relation and the interest rate differential, since in the steady state $E_t \Delta s_t = 0$.

Using this model the hypotheses that the PPP and UIP relations are contained in the cointegrating space can be tested, both separately and jointly, using the hypotheses testing procedure suggested by Johansen and Juselius (1990 and 1992).[19]

6.3. Testing the Order of Integration

Before proceeding further, it is necessary to estimate the unknown order of integration of our variables. There exist a number of tests that enables us to check for unit roots in the series. All these tests try to discriminate between random walk and autoregressive time series processes. This can be demonstrated by a simple AR(1) model:

(6.14) $y_t = \alpha y_{t-1} + e_t$,

where e_t is NID. Random walk behaviour requires that $\alpha = 1$, whereas α less than one in absolute value gives a stationary first-order autoregressive process. To reject the hypothesis that the time series is non-stationary, the coefficient must be significantly less than one, thus the null hypothesis to be rejected is $H_0 : \alpha = 1$, which is equivalent to the hypothesis that y_t is an $I(1)$ process.

To test for unit roots in our series, we use the test proposed by Dickey and Fuller (1979 and 1981), which tests for the null hypothesis of a unit root in an autoregressive model. We use the Augmented Dickey-Fuller test (ADF), which provides a unit root test for a higher-order autoregressive model, both with and without a linear time trend.

The results of these tests are given in table 6.1. For the domestic price series a unit root can be accepted at a five percent level when we use the ADF test with a time trend. For the foreign price level, the exchange rate and both interest rates a unit root

[19] There are several recent papers using the Johansen approach for analysing the PPP and/or UIP relations. Among them are Cheung and Lai (1993), Camarero and Tamarit (1993), Johansen and Juselius (1992) and Juselius (1991).

is accepted at the five percent level using the ADF test without a time trend. We therefore conclude that both sets of prices and interest rates are $I(1)$ series.

Table 6.1. Testing the order of integration; 1979:I - 1991:III
Quarterly data (minus signs omitted)

	p_t	p_t^*	s_t	r_t	r_t^*	$r_t - r_t^*$	λ_t
ADF(2)	3.22	2.57	2.31	1.98	1.56	2.22	2.92
ADF(2) with a time trend	0.96	3.92	1.06	3.50	2.28	3.36	3.30

Note: The null hypothesis is that the series in question are $I(1)$, against the alternative hypothesis of $I(0)$. The rejection criteria at a 5% significant level for ADF(2) without a time trend is 2.92 and for ADF(2) with a time trend 3.51.

We also include a unit root test for the interest rate differential and the real exchange rate. This is of interest since this is just similar to testing for cointegration using the Engle and Granger method. We see that we can reject that the interest rate differential is stationary at a five percent level, indicating no long run relationship between domestic and foreign interest rates using the univariate methodology of Engle and Granger (1987). We can also accept the hypothesis that the real exchange rate is $I(1)$, which indicates that the univariate method would reject the PPP condition as a long run relationship. As mentioned before, these results need not hold when the multivariate Johansen method is used. This is because we are implicitly imposing the restriction that the cointegrating vector is (1,-1,-1) for the PPP condition and (1,-1) for the UIP condition, when we use the Engle and Granger procedure. This can bias our results towards finding no cointegration, since only the correct cointegrating relationship of $I(1)$ series is, in general, stationary. Thus, the findings of non-stationarity of the real exchange rate, for example, can be interpreted as a rejection of the imposed restriction on the underlying equilibrium relationship rather than of the equilibrium condition itself. Further, the restricted models will ignore any possible interactions in the determination of the variables and different short run dynamics in each variable that are allowed for in the unrestricted Johansen model. Distortions due to overwhelming effects from the short run dynamics could prevent any potential long run relationships from being visible.[20]

We conclude, therefore, that the univariate Engle and Granger method does not reveal any support for the PPP and UIP conditions. To make this point further, we

[20]See Cheung and Lai (1993) for further discussions.

show in table 6.2, two examples of such regressions, where we have also included the risk premiums as explanatory variables.

Table 6.2. Results of a cointegration regression; 1979:I - 1991:III
Quarterly data

Dep. variable	Explanatory variables Const.	p_t	p_t^*	s_t	r_t	r_t^*	π_t	μ_t
r_t	-0.467	-0.338	0.298	0.224		-2.104	0.004	0.001

$R^2 = 0.55$; DW = 0.59; ADF(2;trend) = 3.70 (5% critical level = 3.50).

p_t	-7.156		1.712	0.883	-0.132	-0.164	-0.002	0.000

$R^2 = 0.98$; DW = 0.43; ADF(2;trend) = 3.08 (5% critical level = 3.50).

The results of these two models do not suggest any of the proposed economic relations. In the first model there might be some cointegrating vector but the sign of the parameters corresponding to the domestic interest rate does not suggest a UIP relation. In the second model the estimated parameters have the right sign for PPP but the residual vector does not seem to be stationary. Further, the introduction of the risk premiums did not seem to change the results in any significant way.[21]

This illustrates potential difficulties in interpreting the results of many Engle and Granger cointegrating regressions and supports our conjecture of using the Johansen approach when measuring financial integration.[22]

[21]Other models where also tested but gave similar results. Note that t-values are not presented because they are misleading as the variables are non-stationary.

[22]We also tested for unit roots in the monthly data, using ADF(6) with similar results. To test for possible structural changes in the series, we repeated these tests for the data 1984 to 1991. We found no evidence of changes in the time series properties of these series, except that domestic prices are now significantly $I(1)$ without using a time trend in the ADF test.

7. Estimating a Multivariate Error Correction Model

The estimated model is based on a five dimensional VAR system for the vector $X_t = (p_t, p_t^*, s_t, r_t, r_t^*)'$. From the results in chapter 6.3, we conclude that all the variables are $I(1)$. We estimated several versions of this model: without a trend, with a linear trend, with a restricted linear trend (prohibiting the linear trend to pick up a quadratic trend) and various lag lengths.

In this chapter we report the results of two general models with two lags, the first one for the whole period, 1979:I to 1991:III. The second model is estimated for the period 1984:I to 1991:III.

The first step in this analysis is to estimate the unrestricted model to check whether the data support the existence of any long run relations. The next step is to estimate the model under the restriction of the number of cointegrating relations we find and to analyse whether these can be interpreted in terms of the PPP and UIP conditions. It is also of interest is to analyse the error correction parameters, since they will give valuable information on the effects of any disequilibria on the long run relations. A final step is to test for weak exogeneity of some of the variables in the cointegrating space and possibly test the structural hypotheses on the cointegrating space, using the test methods described in Johansen (1991:*a*) and Johansen and Juselius (1990 and 1992).

7.1. Model 1: The Period 1979 to 1991

7.1.1. Testing for Reduced Rank

To test for a reduced rank of the Π matrix, we use the two likelihood ratio tests described in chapter six. For the model estimated for the period 1979:I to 1991:III on quarterly data, the results are shown in table 7.1.

From this table we see that we can safely reject the hypothesis of no cointegration at the standard 5 percent level. The $\hat{\varphi}_{MAX}$ test statistic will lead us to accept only one cointegrating relationship, whereas the $\hat{\varphi}_{TRACE}$ test statistic will lead us to accept two cointegrating vectors. This illustrates the fact that the two test statistics do not necessarily give the same results. Consequently, there is some ambiguity in the decision process due to the low power in cases when the cointegrating relation is close to the non-stationary boundary.[1] Here, we assume that the cointegrating relationships are two. The results of the estimation of these two vectors are reported in the next section.

Table 7.1. Tests of the cointegration rank; 1979:I - 1991:III
Quarterly data

q	$\hat{\varphi}$	Critical values	$\hat{\varphi}_{MAX}$ (0.95)	Critical values	$\hat{\varphi}_{TRACE}$ (0.95)
0	0.935	33.26	134.202	69.98	186.256
1	0.406	27.34	25.522	48.42	52.054
2	0.287	21.28	16.575	31.26	26.532
3	0.174	14.60	9.363	17.84	9.957
4	0.012	8.08	0.593	8.08	0.593

Note: Critical values are from Johansen and Juselius (1990).

7.1.2. The Estimation of the Cointegrating Relationships

In table 7.2 we report the estimates of the two cointegrating vectors and the two error correction vectors.

Table 7.2. The estimates of the α and β matrices for $q = 2$; 1979:I - 1991:III
Quarterly data, normalised

Estimation of the cointegrating vectors

	p_t	p_t^*	s_t	r_t	r_t^*
$\hat{\beta}_1$	1.000	-3.086	-0.498	-12.690	-3.688
$\hat{\beta}_2$	1.000	-4.010	0.172	3.008	8.847

Estimation of the error correction vectors

	p_t	p_t^*	s_t	r_t	r_t^*
$\hat{\alpha}_1$	-0.059	0.003	-0.044	-0.086	0.000
$\hat{\alpha}_2$	-0.018	-0.009	-0.042	-0.125	-0.001

Looking at the estimation results, it is clear that the strict PPP and UIP are not present. In the first cointegration vector we have, however, a PPP type of relationship, with the correct signs on the parameters. But the parameter estimate on the foreign price level is -3, while the parameter estimate on the exchange rate is -0.5. These parameter estimates

[1]See Johansen (1991:*b*). Johansen and Juselius (1992) and Juselius (1991) also face similiar problems.

indicate that the Icelandic real exchange rate has been above its equilibrium value for long periods, as was discussed in chapter four. Presumably, the constantly high inflation in the early part of the estimation period resulted in an overvalued currency, despite frequent devaluations. Thus, the data interprets the long run equilibrium between domestic and foreign prices with parameter values that do not match the hypothetical long run PPP condition, but gives parameter values that are consistent with more than three times higher long run inflation in Iceland during the estimation period. The second vector has, however, incorrect signs for the PPP relationship.

Looking at parameter values of the interest rate variables, it is quite obvious that a UIP relationship is strongly rejected by the data. Not only are the signs the same on both variables, but the parameter values are nowhere near the hypothetical values of unity.

In the second half of table 7.2 we can see the estimation of the error correction vectors. The analysis of these estimates will facilitate a full understanding of the complicated functioning of the system, by giving information on the relative importance of the cointegrating vectors for each equation.

The estimation results seem to indicate that the first eigenvector is the most important one for the domestic price level, the domestic interest rate and the exchange rate, whereas the adjustment process is essentially zero for the foreign price level and interest rate. The second vector is the most important one for the domestic interest rate and the exchange rate, while less important for the domestic price level. Again, the second vector has no significance for the foreign price level and interest rate. Formal testing of this is relegated to section 7.1.4.

On the whole, the estimated error correction parameters suggest, not surprisingly, that the adjustment process is mainly through the domestic price level and interest rate and through the exchange rate, although the adjustment speed was rather slow. The adaptation in the foreign variables towards equilibrium is practically non existent, indicating that these variables are exogenous to the Icelandic financial market. This also indicates that the largest part of the information about the PPP relation (the first cointegrating vector) is in the domestic interest rate equation, which shows the importance of including the interest rate differential as an explanatory variable for the short term adjustment to the long run PPP type of equilibrium.

It is also interesting to analyse the estimated Π matrix. This is shown in table 7.3.

Table 7.3. Estimation of $\Pi = \alpha\beta$ for $q = 2$; 1979:I - 1991:III
Quarterly data, normalised

Equation no.	p_t	p_t^*	s_t	r_t	r_t^*
1	-0.077	0.253	0.026	0.689	0.056
2	-0.006	0.026	-0.003	-0.061	-0.088
3	-0.085	0.302	0.015	0.429	-0.208
4	-0.211	0.767	0.021	0.716	-0.789
5	-0.001	0.003	-0.000	-0.005	-0.009

These estimates measure the combined effect of the two cointegrating relations in each of the five equations in the VAR system. There we can see, as we found in almost all of our numerous estimates, that in almost all equations there is a PPP type of relation, with correct signs but not the hypothetical parameter values. Looking at the domestic interest rate equation, we see what could be accepted as a valid UIP relation, with parameter values of 0.716 and -0.789. We are however somewhat sceptical on accepting this result due to the sensitivity of our findings. When some alterations are done on the basic assumptions of the model, such as lag length, time trend and so forth, this relation completely disappears, which indicates that one should be very careful not to look too hard for the hypothised relationships if one does not want to be found guilty of data mining.

When looking at each equation, we see that in the domestic price equation there is a PPP type of relation and a large effect from the domestic interest rate. For the foreign price equation we see that the largest effect comes from the foreign interest rate, although it is quite small. For the exchange rate equation we see a PPP type of relation and also a UIP type of relation. In the domestic interest rate equation there is a PPP type of relation and the UIP relation mentioned before. For the foreign interest rate equation there are no effects, except maybe from the foreign interest rate itself.

In most of the other estimation results, and also in all the other equations, except the exchange rate and domestic interest rate equation, it is the weighted sum of the interest rates rather than the interest rate differential that matters. This is also what Johansen and Juselius (1992) and Juselius (1991) find for some the equations in their systems. This could be interpreted as giving information of a positive association between the domestic inflation rate and the nominal interest rate, as indicated by the Fisher relation in chapter two.

There are, at least, six possible explanations for the unfavourable findings of the exact PPP and UIP conditions in our data. The first has already been mentioned: the hyperinflation in Iceland during most of the period. This results in a high real exchange rate over the period that produces parameter estimates that do not fit the exact PPP condition.

The second explanation also concerns the PPP condition and is that we use the CPI as our price variable. The problem is that CPI contains a number of goods that are not tradable on international markets. A wholesale price index would be preferable, but such an index does not exist for Iceland.

The third explanation is related to the one just mentioned, and concerns measurement errors. As Cheung and Lai (1993) and Taylor and McMahon (1988) explain, the fact that we are not using the theoretical variables, can result in a rejection of a cointegration relationship. This is because a set of non-stationary variables is generally also non-stationary, except for a small set of variables and parameter values. Using observable variables as proxies for the theoretical ones can, therefore, result in parameter estimates that differ from the hypothetical parameter values of the long run equilibrium. This problem applies to the PPP relation as well as the UIP condition.

The fourth explanation is that our estimation period is rather short and there are therefore not many degrees of freedom. It is well known that the small sample properties of the Johansen method are not well documented. Further, the variance in the residuals is often quite large.

The fifth explanation concerns the UIP condition specifically. As discussed in earlier chapters in this study, interest rates in Iceland have not been market determined until very recently. In fact only the last few observations in our data contain market determined interest rates. Usually interest rates where fixed for long periods and their determination had little or nothing to do with market conditions. The lack of a relationship in our data that can be identified with a UIP type of long run equilibrium is therefore really of no surprise. This does, of course, indicate that the hypothesis financial integration in Iceland can be rejected, as will be discussed in more detail in the conclusions.

The sixth, and final explanation, for the failure of the strict PPP relationship is due to political reasons. It has often been argued that the government were deliberately keeping the real exchange rate high as an indirect resource tax on the fishing industry, since a direct resource tax has not been viewed as politically possible.[2]

[2]See Magnússon (1992) for discussions on these notes.

7.1.3. Diagnostics Results

Here we report some diagnostic statistics for the model. In no case do we find any evidence of skewness or excess kurtosis in the system. Using the Jarque-Bera test statistic for normality we find no evidence to force us to reject the hypothesis of normality of the residuals. We also report test results for heteroscedasticity, using the ARCH test statistic, and the Ljung-Box test statistic for serial correlation. There is no evidence that would lead us to reject the hypotheses of homoscedastic residuals that are independent over time, except for the foreign price level equation where we find significant serial correlation. This could indicate that a VAR(2) is not sufficiently general to catch all the systematic variation in the data or that the information set we use is too small.

The results of both these tests indicate that we can assume that the residuals of all the equations follow a white noise Gaussian process, except perhaps for the foreign price level.[3]

Table 7.4. Residual misspecification tests for $q = 2$; 1979:I - 1991:III
Quarterly data

Variable	R^2	Skewness	Excess kurtosis	Normality test $\chi^2(2)$	ARCH(2) test $\chi^2(2)$	Serial-correlation test $\chi^2(12)$
p_t	0.978	0.544	-0.252	3.006	3.225	5.323
p_t^*	0.780	0.014	-0.545	0.266	4.344	30.660
s_t	0.558	0.492	0.140	2.587	0.158	9.299
r_t	0.611	0.546	0.040	3.053	0.600	6.236
r_t^*	0.110	-0.193	-0.093	0.707	0.270	3.464

Note: The Jarque-Bera normality test and the ARCH(2) test have a critical value of 5.99 at a 5% level. The Ljung-Box test for serial correlation has a critical value of 21.03 at a 5% level.

7.1.4. Testing for Weak Exogeneity

In table 7.3 we saw that the parameter estimates in the foreign interest rate equation are essentially zero, indicating that the foreign interest rate is weakly exogenous. Here we want to test this hypothesis formally and reestimate the model with this restriction, if the hypothesis is accepted.

[3]The assumption of Gaussian errors is only applied in order to use the test statistics. The limit results hold as long as the cumulative sums converge to Brownian motions. See Johansen (1991:*a*).

In chapter six we described the test procedure when testing for weak exogeneity of some of the parameters in the cointegrating space. The test statistic is derived in Johansen (1991:*a*) and is the following:

$$(7.1) \quad -2\ln Q = T\sum_{i=0}^{q}\ln\frac{1-\hat{\varphi}_i}{1-\tilde{\varphi}_i},$$

where $\tilde{\varphi}_i$ are the eigenvalues of the unrestricted model whereas $\hat{\varphi}_i$ are the eigenvalues of the restricted model. This test statistic is asymptotically distributed as $\chi^2(2)$.

We are interested in testing for weak exogeneity of the foreign interest rate. The likelihood ratio test gives 0.04 and we can therefore safely assume that the foreign interest rate is weakly exogenous for the rest of the equation system.

Having accepted the hypothesis of weak exogeneity of the foreign interest rate, we can reduce our equation system to four dimensions without affecting the estimates of the cointegrating relationships.

The results of the estimation of the cointegration relationships with the restriction that the foreign interest rate is weakly exogenous are given in tables 7.5 and 7.6.

Table 7.5. The estimates of the α and β matrices for $q = 2$ when r_t^* is weakly exogenous; 1979:I - 1991:III *Quarterly data, normalised*

Estimation of the cointegrating vectors

	p_t	p_t^*	s_t	r_t	r_t^*
$\hat{\beta}_1$	1.000	-3.085	-0.498	-12.678	-3.664
$\hat{\beta}_2$	1.000	-4.166	0.233	3.153	8.377

Estimation of the error correction vectors

	p_t	p_t^*	s_t	r_t	r_t^*
$\hat{\alpha}_1$	-0.059	0.003	-0.043	-0.086	0.000
$\hat{\alpha}_2$	-0.017	-0.008	-0.044	-0.119	0.000

Table 7.6. Estimation of $\Pi = \alpha\beta$ for $q = 2$ when r_t^* is weakly exogenous; 1979:I - 1991:III *Quarterly data, normalised*

Equation no.	p_t	p_t^*	s_t	r_t	r_t^*
1	-0.076	0.252	0.025	0.689	0.072
2	-0.005	0.025	-0.003	-0.060	-0.077
3	-0.086	0.314	0.011	0.406	-0.208
4	-0.205	0.762	0.015	0.711	-0.685
5	0.000	0.000	0.000	0.000	0.000

We see that there are only minor effects on the estimates of the β and α vectors, except that the error correction term for the foreign interest rate is now restricted to be zero in all equations. This explains the zero values in the last row in the Π matrix in table 7.6.

We also tested some of the structural hypotheses, suggested by Johansen and Juselius (1990 and 1992), that can be used to test economic structural relationships as formulated in terms of the cointegrating relations in β. We tested for the existence of the PPP and UIP relations in the cointegrating space and in all cases did we get negative results, as should be obvious from the estimated β vectors.

Finally, we tested for weak exogeneity of the domestic interest rate and the weak exogeneity of the domestic and foreign interest rate. In both cases are the hypotheses rejected (with p-values of 0.002 and 0.009, respectively).

7.2. Model 2: The Period 1984 to 1991

7.2.1. Testing for Reduced Rank

From table 7.7 we see that the hypothesis of no cointegration can safely be rejected but now we find only one cointegrating relation.

Table 7.7. Tests of the cointegration rank; 1984:I - 1991:III *Quarterly data*

q	$\hat{\varphi}$	Critical values	$\hat{\varphi}_{MAX}$ (0.95)	Critical values	$\hat{\varphi}_{TRACE}$ (0.95)
0	0.982	33.26	116.136	69.98	164.068
1	0.544	27.34	22.753	48.42	47.933
2	0.414	21.28	15.478	31.26	25.180
3	0.278	14.60	9.439	17.84	9.701
4	0.009	8.08	0.263	8.08	0.263

Note: Critical values are from Johansen and Juselius (1990).

7.2.2. The Estimation of the Cointegrating Relationships

In table 7.8 we report the estimation of the cointegration and error correction vectors. Again we find a PPP type of relation, although the parameter estimates do not match those of the hypothetical PPP condition. The dramatic fall in domestic inflation has also caused a change in the relative values of the foreign price and exchange rate parameters, although the estimates still indicate that the long run real exchange rate has been above the equilibrium value indicated by the PPP condition. Again, it is the sum of the interest rates rather than the interest rate difference that constitutes the long run interest rate relation.

Looking at the error correction estimates, we see that the cointegrating vector is most important for the domestic variables, while the adjustment in the foreign variables is very small.

Table 7.8. The estimates of the α and β matrices for $q = 1$; 1984:I - 1991:III
Quarterly data, normalised

Estimation of the cointegrating vector

	p_t	p_t^*	s_t	r_t	r_t^*
$\hat{\beta}_1$	1.000	-0.576	-1.363	-12.500	-6.230

Estimation of the error correction vector

	p_t	p_t^*	s_t	r_t	r_t^*
$\hat{\alpha}_1$	-0.057	0.007	-0.013	-0.053	0.001

Table 7.9 reports the estimation of the Π matrix. There are no dramatic changes. There is a PPP type of relation in all the equation, although it is not significant in the foreign interest rate equation. The estimates are even closer to the hypothetical values than in the first model. The UIP relations found before have, however, completely disappeared.

Table 7.9. Estimation of $\Pi = \alpha\beta$ for $q = 1$; 1984:I - 1991:III
Quarterly data, normalised

Equation no.	p_t	p_t^*	s_t	r_t	r_t^*
1	-0.057	0.003	0.078	0.716	0.357
2	0.007	-0.004	-0.010	-0.093	-0.047
3	-0.013	0.007	0.017	0.159	0.079
4	-0.053	0.031	0.073	0.666	0.332
5	0.001	-0.000	-0.001	-0.008	-0.004

7.2.3. Diagnostics Results

Table 7.10 reports the results of the misspecification tests for model 2. As before, the model passes all the tests, except that we find significant serial correlation in the foreign price equation and that the exchange rate equation now fails the normality test. The reason for this is the high number of devaluations of the krona in this period, which results in an excess kurtosis as can be seen in the table. There is also some excess kurtosis in the domestic interest rate equation, resulting in a near failure of the normality test. This can be explained by the rise of real interest rates from negative to positive values that started in the beginning of this period.

Table 7.10. Residual misspecification tests for $q = 1$; 1984:I - 1991:III
Quarterly data

Variable	R^2	Skewness	Excess kurtosis	Normality test $\chi^2(2)$	ARCH(2) test $\chi^2(2)$	Serial-correlation test $\chi^2(7)$
p_t	0.92	0.860	0.809	4.480	0.056	5.204
p_t^*	0.51	-0.208	-0.484	0.526	4.824	16.186
s_t	0.33	1.591	3.584	11.564	1.089	7.121
r_t	0.41	1.018	2.155	5.963	0.489	4.867
r_t^*	0.13	0.320	1.152	1.008	2.437	2.182

Note: The Jarque-Bera normality test and the ARCH(2) test have a critical value of 5.99 at a 5% level. The Ljung-Box test for serial correlation has a critical value of 14.07 at a 5% level.

7.2.4. Testing for Weak Exogeneity

We tested again for the weak exogeneity of the foreign interest rate. The likelihood ratio test gives a value of 0.06 and thus the hypothesis can easily be accepted. We are also interested in testing the joint hypothesis of weak exogeneity in the domestic and foreign interest rate variables. In this case the likelihood test gives 2.68, which again is less than the critical value. We can therefore accept the hypothesis that both interest rate variables can be treated as weakly exogenous for the period 1984 to 1991.

It is quite interesting that we are now able to accept the hypothesis of weak exogeneity of the domestic interest rate, while we are not able to accept the same hypothesis for the first half of the sample period. If one recollects how the interest rates in Iceland were determined, the explanation is quite obvious. For the first half of the period the government announced the *real* return on government bonds and, thus, the nominal equivalent was determined by the inflation rate. Therefore, the hypothesis of weak exogeneity of the government bond rate in the period is rejected, through the effects of the inflation rate. In the latter half of the sample period, real interest rates became market determined, while the government had some control over nominal rates due to the immaturity of the market.

This, of course, indicates that the domestic monetary authorities had some control over market returns by upholding barriers to capital mobility. This indicates that the hypothesis of total financial integration can be rejected.

In tables 7.11 and 7.12 we report the results of the reestimation of the model with the restriction that domestic and foreign interest rates are weakly exogenous.

Table 7.11. The estimates of the α and β matrices for $q = 1$ when r_t^* and r_t are weakly exogenous; 1984:I - 1991:III *Quarterly data, normalised*

Estimation of the cointegrating vector

	p_t	p_t^*	s_t	r_t	r_t^*
$\hat{\beta}_1$	1.000	-0.566	-1.369	-12.325	-6.155

Estimation of the error correction vector

	p_t	p_t^*	s_t	r_t	r_t^*
$\hat{\alpha}_1$	-0.050	0.008	-0.016	0.000	0.000

Again we find a PPP type of relation and no evidence of a UIP relation. The parameter estimates are quite similar to those before and the estimations of the error correction parameters indicate that any adjustment toward long run equilibrium is quite slow.

Table 7.12 reports the estimation of Π. Now the last two rows contain only zeros. Note that we have in the domestic price equation, a PPP relation with correct signs and parameter values that could pass for the hypothetical values.

Table 7.12. Estimation of $\Pi = \alpha\beta$ for $q = 1$ when r_t^* and r_t are weakly exogenous; 1984:I - 1991:III *Quarterly data, normalised*

Equation no.	p_t	p_t^*	s_t	r_t	r_t^*
1	-0.050	0.028	0.068	0.613	0.304
2	0.008	-0.005	-0.011	-0.101	-0.050
3	0.016	-0.009	-0.022	-0.201	-0.100
4	0.000	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000	0.000

7.3. Introducing Risk Premiums to the Cointegration Analysis

As discussed in the previous chapters, there are both empirical and theoretical evidence that supports the rejection of the implicit assumption of the basic UIP and CIP conditions of risk neutrality. We have discussed two types of risk premiums. The first one is the risk attached to uncertain future exchange rate movements that introduces a wedge between the forward rate and the future spot rate, as described in equation (2.25). Here, we have proposed a proxy measure for this risk premium as the relative standard deviations in the real exchange rate of the krona and the global rate. This proxy can be seen in figure 5.9. The proxy shows considerable fluctuations over time and is not easy to interpret.

What we are interested in is whether this exchange rate risk premium has any effect on the long run properties of our model, that is, if the risk premium is significant or has significant effect on the cointegrating results for the VAR model in (6.6).

Lately, it has been suggested that a convenient way to capture a time varying exchange rate risk premium is to use the autoregressive conditional heteroscedasticity (ARCH) modelling procedure.[4] In this way we can allow for a time varying risk premium that will depend on the degree of uncertainty in the system.[5]

To explain the ARCH modelling procedure, we can take a simple example.[6] Suppose that the residual in (6.6), ξ_t, has a time varying variance, $\sigma^2_{\xi t}$, and that the exchange rate risk premium, μ_t, is positively related to $\sigma^2_{\xi t}$ in a linear fashion:

$$(7.2) \quad \mu_t = k_0 + k_1 \sigma^2_{\xi t}.$$

To complete the model we need to determine the relation between $\sigma^2_{\xi t}$ and ξ_t. A simple way to do this is to assume that $\sigma^2_{\xi t}$ is a linear function of recent lagged squared ξ_t:

$$(7.3) \quad \sigma^2_{\xi t} = g_1 + g_2 \sum_{j=1}^{m} \xi^2_{t-j}.$$

By substituting (7.3) into (7.2) we get an ARCH(m) model that can be estimated with non-linear maximum likelihood.

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[4]An alternative way, not pursued here, is to look for non-linearities in the VAR model that could be interpreted as evidence for a non-linear exchange rate risk premium.

[5]See, for example, Chou (1988) and Hall, Miles and Taylor (1989). See de Vries (1993) for a survey.

[6]This discussion is based, in part, on Cuthbertson, Hall and Taylor (1992), p. 79 - 82.

In our estimated VAR model above we test for evidence of a significant ARCH(2) component in the error terms. In all cases do we find that the ARCH test gives values that are significantly less than the critical value, although the values are considerably higher in both the price equations in model 1 and in the foreign price equation in model 2. This lack of a significant ARCH component in the model indicates that the exchange rate risk premium is not important in explaining the (lack of) cointegrating relations in the estimated VAR model above.

The second risk premium we have analysed, is the risk attached to uncertain future government actions that can have substantial effects on the expected returns of foreign investors, contemplating investment in Iceland. We have suggested two proxies for this risk premium. The first one is a reputational factor, calculated as the frequency of market interventions during the last year. The second risk factor captures the potential need for future interventions and is calculated as the relative foreign net indebtedness of Iceland.

To analyse whether these risk premiums have any impact on the long run equilibrium properties, we suggest that a convenient way to proceed is simply to regress these premiums on the estimated residuals of the VAR system. The estimated residuals can be considered as prewhitened and, thus, the usual correlation analysis will be appropriate.[7]

The regression equation is therefore:

$$(7.4) \quad \hat{\xi}_t = b_0 + b_1\mu_t + b_2\mu_{t-1} + b_3\pi_{1t} + b_4\pi_{1t-1} + b_5\pi_{2t} + b_6\pi_{2t-1} + \eta_t,$$

where π_{1t} is the frequency proxy for political risk, π_{2t} is the indebtedness proxy and η_t is an error term. In table 7.13 we report the results of such regressions.

Table 7.13. Regressions on the residuals of the VAR system; 1979:I - 1991:III

Quarterly data

	Regression equations				
	p_t	p_t^*	s_t	r_t	r_t^*
R^2	0.13	0.05	0.25	0.13	0.16
$F(6,42)$	1.06	0.33	2.31	1.05	1.35

There we can see that the proxies for political and exchange rate risk do not seem to contain any relevant additional information concerning the long run properties of the

[7]Generally, if the cross correlation function between two time series is estimated, the usual t-statistics will not give correct inference. Prewhitening is therefore necessary. See, for example, Brockwell and Davis (1991).

model, as all the regression have low explanatory power and have insignificant F values. A possible exception could be the exchange rate equation (with a p-value of 0.05). The reason for this could be that a sudden change in the political risk premium (the indebtedness proxy) is followed by a change in the residual in the exchange rate equation.

One the whole, however, the evidence for any significance of the risk premium for our results in the cointegration analysis is scarce. We therefore conclude that the political and exchange rate risk premiums do not seem to contain any additional information that can help explain the deviations from the long run equilibriums, as suggested by the PPP and UIP relations.

A possible explanation for this result is that our risk premium proxies are not correctly specified in some way. Another possible explanation is that these risk premiums might be important for short run investment decisions, as discussed in chapter five. A formal test of this hypothesis is, however, only possible with explicit modelling of the demand for risk premiums by international investors.

Part V. Conclusions

The objective of this study is to try to test for the existence of financial integration between Iceland and the global financial market, and to try to measure the level of this integration, if it exists. This is done by using a model that enables us to describe the inherent tendency to move towards the long run equilibrium, without necessarily ever reaching it, due to frequent and often large shocks pushing it away from the equilibrium path.

Our study can be divided into two parts, the first half analysing the short run dynamics of the Icelandic financial market and the latter half analysing the long run properties of the market.

Our main conclusions from the first and second half are, respectively:

A. The short run dynamics

1. Interest rate dynamics

Nominal interest rates were rather stable in the period 1974 to 1984, but had a positive trend, due to rising inflation. After 1984 interest rates became much more volatile, but the volatility has been decreasing since the start of the 1990s. This is in line with the experience of the other Nordic countries, although Icelandic nominal interest rates seem to be much more volatile than their nordic counterparts.

Until 1984 real interest rates were generally negative and often substantailly so. After 1984 they generally became positive and have since then been often very high. Over the whole period real exchange rates have been very volatile, although the volatility has decreased substantially since the beginning of the 1990s. This is also in line with the experience of the other Nordic countries.

2. Exchange rate dynamics

The value of the Icelandic krona has diminished substantially over the sample period. Against the major currencies analysed in this study the average depreciation has been around 2 percentages a month from 1974 to 1992. The depreciation of the krona has, however, decreased substantially since 1989. The volatility of the nominal exchange rate has also decreased somewhat since 1989. The distribution of the nominal rates is found to be highly skewed towards depreciations against all currencies, and in all cases do they have a larger probability mass in the tails than can be expected for normally distributed processes.

The real exchange rate has for the most part of our study been high, indicating an overvalued currency. There have been large fluctuations in the real exchange rate over the period, although the volatility of the real exchange rate has diminished since the start of the 1990s.

3. The dynamics of the interest rate differential

Nominal interest rates have been higher in Iceland than in the other countries analysed. However, due to large expected exchange rate depreciations, the expected return on domestic investment has been lower than expected abroad. Since large movements of capital abroad has not been observed, this indicates that capital control have mainly operated in preventing outward movements of capital. This has resulted in large and frequent interest rate differentials.

After 1984 there seem to be substantial decrease in the interest rate differential, mainly due to decreased expected exchange rate movements. The volatility of the interest rate differential has also been decreasing since 1984. The fact that there seems to be a major change in 1984, even though formal deregulation took much longer time, could well indicate that restrictions of capital movements were not as effective *de facto* as they were *de jure*.

4. The risk premiums

Our proxy for exchange risk indicates that the volatility of the krona was less than of the foreign counterpart, with the least risky periods in 1983 to 1985 and 1988 to 1989. This indicates that the relative risk of the krona was less than of the global rate. This, perhaps surprising, result can be explained by the often substantial volatility of the dollar and the fact that the krona has not been on the market and therefore not subject to speculative attacks. Another reason could be that the foreign rates have been floating for most of the period, whereas the krona has been formally fixed.

The political risk indicates that political instability reach its peak the period 1983 to 1985, which is a low point for the exchange rate risk premium. This could well indicate a tradeoff between these two risk premiums, since reducing the exchange rate risk could result in an increase in political risk.

B. The long run properties

5. Long run relationships

We find some evidence that supports a PPP type of relationship as a long run equilibrium condition although the hypothetical parameter values are rejected by the data, mainly due to the high inflationary history of Iceland in most of the period that has resulted in a consistently high real exchange rate. When the model is estimated for the period 1984 to 1991, with the restrictions that domestic and foreign interest rates where weakly exogenous, parameter values closer to those of the hypothetical PPP condition are found.

The evidence for the UIP relationship is much weaker, however. In only few cases do we find that the cointegrating vectors include a relation that is close to the UIP relation, in most cases the relationship has the wrong sign and is often insignificant.

We do, however, find that it is important to include the interest rate differential as an explanatory variable for the short run dynamics towards the long run PPP type of relation.

6. Possible weakly exogenous variables

Our results indicate that the foreign interest rate can be treated as weakly exogenous in our equation system for the whole period. This is what should be expected since we are analysing a very small market which should not be expected to the determination of international interest rates.

We also find that the domestic interest rate can be treated as weakly exogenous for the period 1984 to 1991 but not for the period prior to 1984. The reason for this is that real interest rates were determined by the government more or less until 1984, which made the nominal equivalent endogenous through the inflation rate. In the latter half, however, the government lost its control over real interest rates but in turn tried to control nominal rates to some extent. This indicates that the domestic monetary authorities had some policy autonomy and that total financial integration did not prevail in Iceland during the period in question.

7. *Structural changes in the mid 1980s*

As mentioned above, we find some evidence of a structural change in the short run interest rate determination process in the middle of the 1980s, due to the institutional changes that started in that period.

There is, however, no evidence of any decrease in the long run deviations from the hypothetical UIP condition. On the contrary, domestic interest rates seem completely independent from foreign influences in the long run. The reason for this is most likely that it is not until 1990 with the emergence of bond- and interbank markets that we really have market determined interest rates even though the process towards market determination of interest rates started in 1984. It should, however, be pointed out that in the latter period we have relatively few degrees of freedom in our estimation process. This prevents us from analysing shorter periods.

8. *The speed of adjustment towards the long run equilibrium*

Theory states that the speed of adjustment in the goods markets should be relatively slow, while the adjustment in the asset markets should be fast. We find that in general that the adjustment speed is very slow. Not surprisingly do we find that the adjustment speed in the foreign variables is essentially non-existant. The adjustment in the domestic variables towards the hypothetical relations is also rather slow, indicating again the lack of financial integration in Iceland. This also supports the theoretical statement of sticky domestic prices.

There seems to be no evidence of an increased adjustment speed towards the long run equilibriums in the latter part of the estimation period.

9. *The effects of the risk premiums on the long run results*

It is often stated that the main reason for the failure of the basic UIP relationship is the importance of political and exchange rate risk premiums. With this in mind we try to find whether these risk premiums have any impact on the hypothetical long run relationship between domestic and foreign interest rates.

Our results indicate that neither of the risk premiums have any effect on the long run properties of the model. We test whether there is any evidence of a time varying exchange rate risk premium. The results of these tests are negative. We also test whether the residuals of the VAR model can be explained by the risk premiums and find that the risk premiums seem to contain no additional information on the long run properties of the model.

A possible explanation for this is that our proxies for these risk premiums are somehow incorrectly specified. Another explanation is that these risk variables mainly influence the short term behaviour of international investors, which is not catched properly in our model. Formal inference on that hypothesis demands explicit modelling of risk averse international investors, which is outside the goals of this study.

10. Implications for financial integration

Our results clearly reject any total or direct financial integration between Iceland and the rest of the world. Nor do we find any evidence of an increase in financial integration. The only possible link with foreign financial markets is through the PPP type of condition that we find. Thus, there is some weak evidence of indirect financial integration between Iceland and the rest of the world, through the commodity markets.

The view held by some, that the Icelandic financial market had already started to integrate with the world financial markets as early as the mid 1980s is therefore soundly rejected by our model. We find no evidence of any form of financial integration in the period 1978 to 1992 or in the subperiod 1984 to 1992.

What should be interesting is to repeat this study in a few years time, using data from 1990 onwards. This might give totally different results, due to the dramatic structural changes that have recently occurred in the Icelandic financial market resulting in a more open financial market and interest rates that are more useful for an analysis such as this one.

Appendix

In this appendix, we describe the relevant time series used in our study.

A.1. Interest Rate Series

We use four interest rates: three short term rates and one long term rate. The short term rates are prime rates, discount rates and treasury bills rates. The long term rate is the government bond rate.

Prime Rates

Prime rates are available for all the countries used in our study. The series for Sweden, Finland, Danmark, U.S.A., U.K., Germany and Japan are all monthly data taken from *World Financial Statistics* (Morgan Guaranty). For Iceland the prime rate has only existed from 1990. We therefore approximate it as the general short term commercial lending rate, adjusted by 1.7 percentages, which is the average difference between the commercial rate and the prime rate between 1990 and 1992. The difference remained very stable over the period (monthly data, Central Bank of Iceland). For Norway we approximated the prime rate as the three month special term deposit rate for the period 1974:1 - 1986:10 (Morgan Guaranty) and the short term lending rate to the public of commercial banks for the period 1986:4 - 1991:3 (quarterly data, Bank of Norway).

The weighted world rate is constructed using the U.S., U.K., German and Japanese prime rate using trade weights.

Discount Rates

Discount rates are available for Sweden, Finland, Danmark, U.S.A., Germany and Japan. For the U.K. and Norway the discount rate only existed until 1979 and 1984, respectively. These series are all monthly data and come from the *Main Economic Indicators* (OECD). For the U.K. we use the minimum lending rate after 1979 (monthly data, Bank of England) and the daily loan rates for Norway after 1984 (monthly data, Bank of Norway). The discount rate exists on monthly basis for Iceland for the whole period (Central Bank of Iceland).

The weighted world rate is constructed using the U.S., U.K., German and Japanese prime rate using trade weights.

Treasury Bills Rate

The treasury bills rate for the U.S., Japan and the U.K. come from *World Financial Statistics* (Morgan Guaranty). The data for Germany come from the Bundesbank (the Frankfurt rate). For the Danish treasury bills rate we use the three month money market rate for the period 1976:9 - 1988:8 (Denmark Nationalbank) and the three month interbank rate for the period 1988:9 - 1991:10 (OECD). For the Finish treasury bills rate we use the three month forward FIM interest rate for the period 1974:1 - 1986:12 (Bank of Finland) and the three month HELIBOR rate (Helsinki interbank offered rate) for the period 1987:1 - 1991:12 (Bank of Finland). For the Norwegian treasury bills rate we use the three month money market rate (Morgan Guaranty) and the three month NIBOR rate (Norwegian interbank offered rate) (Bank of Norway). For Sweden the treasury bills rate exists for the period 1974:1 - 1982:9 (Morgan Guaranty). From 1982:10 we use the rate for treasury discount notes with 90 days outstanding maturity (The Swedish National Debt Office). Finally, for Iceland the treasury bills rate have been registered in the periods 1984:1 - 1984:11, 1985:1 - 1985:2 and from 1990 to 1992. All the series are on monthly basis, except quarterly data for Danmark until 1976:9.

The weighted world rate is constructed using the U.S., U.K., German (the Frankfurt rate from 1982) and Japanese prime rate using trade weights.

Government Bonds Rates

We use the rate on government bonds that have five years maturity. The data for the U.S., Germany, Japan, Denmark, Norway, Sweden and the U.K. come from *International Financial Statistics* (IMF). The data for Finland come from the *Main Economic Indicators* (OECD). Government bonds rate for Iceland are only annual data on real returns from 1974 to 1986. The nominal equivalent is calculated using the Fisher relation.

The weighted world rate is constructed using the U.S., U.K., German (the Frankfurt rate from 1982) and Japanese prime rate using trade weights.

A.2. Exchange Rate Series

The nominal exchange rate is calculated as the end of month official rate of the ISK against the USD, the JPY, the DEM, the GBP and the CHF. These are indices of monthly data from 1974 to 1992, using 1974:1 as base year.

The nominal effective exchange rate is calculated using the 17 currencies in the Icelandic currency basket, using average trade weights over the period.

For the real exchange rate the year 1979 is chosen as equilibrium point. The data come from *International Financial Statistics* (IMF).

A.3. Price Indeces

We use the Consumer price index (CPI) to measure prices for all the countries. The data come from *International Financial Statistics* (IMF) and from the Statistical Bureau of Iceland for Iceland.

The inflation rates are calculated as the percentages difference during the last three months.

The weighted world rate is constructed using the 17 currencies in the Icelandic currency basket, using average trade weights over the period.

A.4. Other Time Series

Political Risk

The frequency of changes in market rules for Iceland come from *Annáll Efnahagsmála* (National Economic Institute, Central Bank of Iceland). This serie is from 1979:1 to 1992:6.

The relative debt series for Iceland come from the Central Bank of Iceland and from Oxelheim (1993), for the other countries. These series are on quarterly basis, from 1977:4 to 1991:4.

Exchange Rate Risk

The data for the exchange rate risk for Iceland come fromt the Central Bank of Iceland. Data for the other currencies come from Oxelheim (1993). These series range from 1977:12 to 1991:6.

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