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Effectiveness of Capital Controls in a Financial Crisis: The Case of Iceland

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ABSTRACT

The purpose of this thesis is to evaluate the effectiveness of the capital controls on outflow implemented in Iceland in October 2008 following a severe systemic crisis caused by the default of the three largest Icelandic banks. Specifically, we assess to what extent Icelandic capital controls curtailed capital outflows, supported the ISK, reduced exchange rate fluctuations, and increased monetary policy independence. A GARCH model on daily nominal exchange rates is employed, and we found that Icelandic capital controls stabilized the exchange rate and prevented further depreciation of the domestic currency. However, capital controls did not seem to enhance monetary autonomy. Regarding the effectiveness of capital controls in reducing outflows, the empirical results from a panel fixed effect model on capitals flows and descriptive statistics were largely inconclusive. Furthermore, the amendments to the capital controls that directly addressed leakages to the unofficial off-shore exchange rate market appear to have been successful in increasing the risk premium for circumvention. We conclude that although capital controls in Iceland did not achieve all of their policy objectives, they may indeed have been a necessary policy response to the financial crisis.

Keywords*:* Capital Controls, Iceland, Financial Crisis, GARCH, Capital Flows, Exchange Rate Volatility

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Prologue

It was the morning of October 7th, 2008, at the Economic Research Department of Landsbanki, downtown Reykjavík – I remember the meeting like it was yesterday.

The atmosphere at the office was electrified. No one knew how to act as we had just found out that the Icelandic government was about to take over the bank that we were working at since it had run out of liquidly and was unable to fulfill its obligations. In the meeting room with me were three senior economists from the research department, and the topic discussed was simple; what could be the worst case scenario going forward? The discussion covered some daunting suggestions: a wave of unavoidable bankruptcies, hyperinflation, mass emigration, possible shortage of imported goods, and *capital controls*.

I knew the outlook of the bank and Icelandic economy was bleak at this point, but the scenarios discussed were too inconceivable for my brain to register. At first, the economic situation sounded like a bad joke that had gone out of hand, and I was convinced that my colleagues had to be kidding about the future scenarios discussed. However, the severity of the situation soon dawned on me.

I had indeed read about capital controls in an economic history class at the university, but that was all in past tense, and controls sounded like a long outdated policy tool. Little did I know that I was about to experience such a period of capital restrictions in my very own country...

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List of abbreviations

ARCH ..... Autoregressive conditional heteroskedasticity
CBI ..... The Central Bank of Iceland
CC ..... Capital Controls
CCSU ..... Capital Controls Surveillance Unit
CDS ..... Credit default swap
FDI ..... Foreign Direct Investment
FSA ..... The Financial Supervisory Authority
FX ..... Foreign Exchange
GARCH ..... Generalized autoregressive conditional heteroskedasticity
GDP ..... Gross domestic product
IIP ..... International Investment Position
IMF ..... The International Monetary Fund
ISK ..... The Icelandic krona
OLS ..... Ordinary least square
O/N ..... Over Night
REIBOR ..... Reykjavik Interbank Offered Rate
RER ..... Real exchange rate
US fed ..... United States Federal Reserve
VIX ..... Chicago Board Options Exchange Market Volatility Index

1. Introduction

The aim of this thesis is to evaluate the effectiveness of the capital controls on outflow implemented in Iceland at the peak of the financial crisis in 2008. In October 2008, Iceland got into the worldwide news as it was hit with a severe systemic crisis following the collapse of its three major banks. The collapse of the banking system was an enormous hit for the economy, which was reflected in the depreciation of the ISK by more than 20% in one day, free fall of the Icelandic stock market, and a skyrocketing credit default swap (CDS) spread for the Icelandic government (CBI, 2010d).[1] The loss of confidence in the Icelandic economy following the collapse of the banking system and the accompanied uncertainty about how the situation would be solved threatened to trigger large capital outflows, even further depreciation of the ISK, and consequently higher inflation. Such consequences would have generated an even more severe wave of bankruptcies of both households and companies due to the high leverage and exposure to foreign exchange risk. As a result of this serious threat, the Central Bank of Iceland (CBI) was forced to introduce temporary measures to limit all currency trades in order to reduce the outflow of capital and halt further depreciation of the ISK; capital controls were implemented (CBI, 2010d). In this thesis, we will analyze if the capital controls were effective in reaching the goals that motivated their imposition. Specifically, we will attempt to answer the question *whether Icelandic capital controls on outflow did, in fact, curtail capital outflows, support the ISK, reduce exchange rate fluctuations, and increase monetary policy independence.*

The topic of capital restrictions is currently a hotly debated economic issue, which makes this thesis relevant to today's policy discussion regarding economic crisis management. As capital controls have gone in and out of fashion in both developed and developing countries for more than a century, the financial crisis in 2008 once again sparked some interest in this policy tool, and capital control surfaced on the economic agendas of policy makers. The capital controls in Iceland have caught attention as an episode indicating a sharp turn in policy recommendations by the IMF, who supported the controls as an integrated part of the Icelandic government's IMF facilitated economic recovery program. Until then, the IMF had for quite some time been very clear about their stand against capital controls on outflow (Chwieroth, 2010).

Although the use of capital controls on outflow as a policy tool dates back several decades, their effectiveness is not well understood and the empirical results are inconclusive. In part, the inconclusiveness of the empirical research is influenced by the fact that the set of episodes of capital

[1] CDS is a swap designed to transfer the credit exposure of fixed income products from one party to another. The CDS spread is the annual premium the buyer of the protection needs to pay. The higher the premium, the more likely the market evaluates a default of the issuer of the underlying asset.

controls on outflow analyzed in the literature is limited and heavily dominated by the capital restriction episodes in Malaysia (1998) and Thailand (1997).

Moreover, to the best of our knowledge, there has been no prior formal empirical evaluation of the effectiveness of capital controls on outflow in Iceland.[2] Furthermore, there is not only a lack of research about the specific case of Iceland, but little empirical research has been done on the effectiveness of capital controls in developed countries in general. The high quality of institutions in developed economies should make them better equipped than emerging countries to enforce capital controls (Binici et al., 2009). However, deeper integration into global financial markets and highly developed domestic financial markets can make the enforcement of controls more difficult since sophisticated (and typically large) investors have a broader range of possibilities to evade the controls (Demirguc-Kunt & Serven, 2010). Thus, the effectiveness of capital controls in a developed country context appears to be a double-edged sword and it is not clear what degree of success to expect of the Icelandic controls.

Furthermore, we will contribute to research by using empirical models that have traditionally not been applied when evaluating capital controls on outflows. Thus, we aim to contribute to research by diversifying both the context and methods by which capital controls on outflow have traditionally been analyzed and hopefully shed some light on the effectiveness of this controversial policy tool.

This paper is structured as follows. In the following section, we discuss the previous empirical literature on capital controls on outflow. Section three introduces the main characteristics of the Icelandic economy, the development that led to the financial meltdown in 2008, and the key events during and following the crisis. Section four addresses our research hypotheses in more detail, and in the fifth section, we analyze descriptive statistics of key economic variables. Section six covers the empirical model used to address our research question, and section seven elaborates on the data adjustments needed and empirical challenges encountered. In section eight, the empirical results are presented. Finally, in section nine we make some concluding remarks.

[2] Central Bank of Iceland staff claim in the media that the controls are being effective; however, they do not refer to any formal analysis nor is any formal evaluation published (RÚV, 2010). Furthermore, Zoega (2009) has in a working paper derived the relationship between central bank interest rates and exchange rates under the capital control regime in Iceland. However, his study does not analyze the effectiveness of capital controls in achieving their stated policy goals.

2. Literature Review

Although the empirical literature on capital restrictions on outflow covers a wide time span with controls in different contexts, the effectiveness of capital controls on outflow is still not very well understood and empirical results have been mixed. In a comprehensive overview of the empirical literature on capital controls provided by Magud and Reinhart (2006), they find little conclusive evidence of the effectiveness of capital controls on outflow, regardless of how successful controls are defined. The episode of capital controls in Malaysia (1998) seems to stand out as the poster child for effective capital controls on outflow as they were actually successful in reducing outflow and allowing for a more autonomous monetary policy (Magud & Reinhart, 2006). However, several researchers have attributed the Malaysian success story to the timing of controls. Malaysian capital controls were implemented late in the Asian crises when the economy had already started to recover and the worst turmoil was over, and some economists argue that this is the reason why the Malaysian episode has been measured as more successful in the empirical literature (Demirgüç-Kunt & Servén, 2010; Edison & Reinhart, 2001a). Regarding the timing of the Icelandic capital controls, they were initially implemented in mid-October 2008 right after the Icelandic banking system collapsed and while financial turmoil and risk sentiments were at its highest in international markets. Compared to the frequently cited episodes of controls on outflow in Malaysia (1998) and Thailand (1997), the timing of Icelandic capital controls seems to be more similar to Thailand who implemented their controls before the peak of the Asian crisis. Therefore, based solely on the argument that Malaysian capital controls has been measured as successful because of their timing, we would expect the results of the empirical analysis of Icelandic capital controls to have more in common with controls in Thailand than controls in Malaysia.

One point worth emphasizing regarding research on capital controls is that it has low external validity. Since capital controls tend to have different policy objectives and are implemented in country-specific contexts, the results of the empirical research is episode specific, and one should be careful making any generalized policy recommendations based on the results (Kamil & Clements &, 2009).

To analyze the effectiveness of capital controls, researchers have used a number of different methods, which to a large extent have depended on the frequency and quality of the data available. In a study by Ariyoshi et al. (2000), descriptive statistics are employed to perform a qualitative analysis of the effectiveness of capital controls in Malaysia (1998), Spain (1992), and Thailand (1997) in reducing capital outflow. Ariyoshi et al. conclude that controls have only had a temporary effect in reducing outflows and at best, provided authorities with the time needed to address macroeconomic imbalances and implement structural reforms. Effective capital controls, they argue, must be

accompanied by other reforms and furthermore, be comprehensive enough and strongly enforced in order prevent circumvention.

In a study by Edison and Reinhart (2001a), the effectiveness of controls on outflow in Malaysia (1998) and Thailand (1997) is evaluated. In their analysis, Edison and Reinhart employ descriptive statistics on the mean, variance, and persistence of the exchange rate, interest rate, and capital flows pre- and post-controls. Furthermore, a generalized autoregressive conditional heteroskedasticity (hereinafter GARCH) model with interest rates is used to assess the impact of controls on the volatility of domestic interest rates. The effectiveness of capital controls in Malaysia and Thailand stand in sharp contrast to each other. Edison and Reinhart conclude that in Malaysia, capital controls on outflow lived up to their expectations of greater exchange rate stability, lower and more stable interest rates during the control period, and thus increased monetary policy autonomy. However, controls do not seem to be associated with lower capital flows. The drawback of their analysis is that the data set used only includes capital flows to and from the United States, which might give a skewed picture of aggregate capital flows. This problem is recognized by Edison and Reinhart as they admit that the U.S. was perhaps not the main source of capital flows in Malaysia and Thailand around the time of the controls.

In contrast to Malaysia (1998), Edison and Reinhart (2010a) conclude that the volatility of exchange rates in Thailand (1997) increased during the control period, and controls in Thailand were neither able to lower the interest rate level nor reduce volatility spillovers. In addition, Edison and Reinhart's analysis suggests that capital flows in Thailand increased in the period when controls where in place. They argue that the ineffectiveness of Thai controls might be due to Thailand's inability to prevent leakages and evasion of the controls. Furthermore, Edison and Reinhart attribute the difference in results between Malaysia and Thailand to the timing of capital controls. Capital controls were applied after the peak of the crisis in Malaysia, while in Thailand it was done at earlier stages during the economic crisis. Thus, the implied effectiveness of Malaysian controls can, in fact, be due to a general reversal of domestic economic conditions around the same time as controls were implemented (Edison & Reinhart, 2001a).

The shortcomings of Ariyoshi et al. (2000) and Edison and Reinhart (2001a) are that no formal econometric analyses are conducted when evaluating the effectiveness of capital controls in stabilizing the exchange rate and reducing outflow. Since the descriptive statistics employed do not take into account any domestic or external factors that could possibly impact the exchange rate volatility and the volume of capital flows, they fail to isolate the effect of capital controls per se on the exchange rate and capital outflow.

Tamirisa (2004) uses a more rigorous econometric framework to analyze the macroeconomic effects of capital controls in Malaysia in the 1990s. An error-correction model controlling for capital controls, external factors, and domestic factors is used to assess the impact of controls on monthly real exchange rates. Tamirisa's findings regarding the effectiveness of capital controls on outflow stand in sharp contrast to the findings of Reinhart and Edison (2001a). With regards to controls on outflows, according to Tamirisa, the analytical results suggest that "the effect of all capital controls on the real exchange rate was statistically insignificant" (2004, p.18).

Although Tamirisa (2004) employs more rigorous econometric techniques compared to Edison and Reinhart (2001a), her method is biased toward finding that capital controls were ineffective in stabilizing the exchange rate since the monthly data used fails to account for daily fluctuations in volatility. By measuring the exchange rate volatility on a monthly basis, daily demand and supply pressures that cause the exchange rate to fluctuate are ignored, thereby increasing the likelihood of finding that capital controls on outflow are unsuccessful in stabilizing the exchange rate. Furthermore, none of the empirical studies on capital outflow restrictions we have encountered control for the daily determinants of exchange rates or explicitly model exchange rate volatility.[3] To fill this void in the empirical literature and to address the shortcomings the use of monthly data give rise to in Tamirisa (2004), we will employ a GARCH model with daily nominal exchange rates to examine the impact of Icelandic capital controls on the exchange rate. The GARCH model allows us to explicitly model both the level and volatility of exchange rates while controlling for domestic and international determinants of the exchange rate. Thus, compared to previous studies, we can more effectively isolate the impact of capital controls on outflow per se on both the level and volatility of the exchange rate. Furthermore, by using daily frequency data, we are able to control for the demand and supply pressures that could possibly impact the exchange rate on a daily basis, which studies using lower frequency data fail to account for.

In contrast to previous studies reviewed, a study by Binici et al. (2009) suggests that capital controls on outflow are, in fact, able to reduce outflow. Binici et al. use a panel fixed effect model comparing 74 countries during 1995-2005 to determine the effectiveness of capital account restrictions. A panel data set with yearly observations is employed that distinguished between net capital inflow and net capital outflow. Binici et al. claim that by disaggregating net capital flow into net inflow and net outflow, research can provide richer insight into the effectiveness of capital controls on outflow. They find that "both debt and equity controls can substantially reduce outflows, […] but only high-

[3]Kamil (2008), Coelho and Gallagher (2010), and Kamil and Clements (2009) all use GARCH models in their studies on capital controls on *inflow* to analyze exchange rates; however, such an analysis has to our knowledge never been employed to analyze the effectiveness of capital controls on *outflow.*

income countries appear able to effectively impose debt (outflow) controls" (Binici et al., 2009, p.1). The results indicate that capital controls appear to be more effective in developed country settings compared to emerging markets and developing countries. Binici et al. attribute the results to higher-quality institutions in developed economies, which lead to an increased ability to enforce the controls.

Although Binici et al. (2009) claim that analyzing disaggregated capital flows can give rich insight into the effectiveness of capital controls on outflow, their analysis suffers from two serious data issues, which raise concerns regarding the conclusiveness of their results. First, the low frequency of data is an issue; the yearly observations of net capital flow can be a poor estimation of the true underlying capital flows since it fails to reflect short- and medium-term changes in capital flows (less than one year). Second, the disaggregation of capital flow into net outflow and net inflow is derived from the stock-oriented International Investment Position (IIP) and therefore, includes valuation changes rather than international capital transactions exclusively.[4] Thus, a change in net capital outflow can be attributable to (1) cross-border capital transactions and (2) valuation changes of financial assets and liabilities. Hence, in our opinion, Binici et al.'s analysis provides an incomplete estimation of capital controls' effects on capital outflows.

In our analysis of Icelandic capital controls, we will attempt to address the shortcomings of Binci et al. (2009) by employing a data set with quarterly observations on overall capital flows drawn from the Balance of Payments accounts. Quarterly data allows us to capture medium-term fluctuations in capital flows, which annual data does not. Furthermore, by using net capital flow data from the Balance of Payments rather than disaggregating stock data from the International Investment Position, we effectively eliminate any measurement effects that may arise due to valuation changes. Thereby, we hope to be able to more accurately quantify the effectiveness of capital controls in reducing outflow.

The empirical studies reviewed in the above sections clearly demonstrate how the estimated effectiveness of capital controls can vary depending on what analytical method or data set is employed. Furthermore, the reviewed literature emphasizes the importance of comprehensive controls and strong enforcement in order for the controls not to be circumvented (Ariyoshi et al., 2000; Edison & Reinhart 2001a). But despite the fact that ineffectiveness of capital controls can largely be attributed to restriction being evaded due to some loopholes in the legislation and/or lack

[4] The International Investment Position (IIP) measures the value of the stock of a country's financial assets and liabilities. "A change in stocks during any defined period can be attributable to transactions (flows); to valuation changes reflecting changes in exchange rates, prices, etc.; or to other adjustments (e.g., uncompensated seizures)" (IMF, 1993, p.6) . In contrast, the accounts in the Balance of Payments only reflect capital transactions (IMF, 1993).

of enforcement of the controls, the literature on capital controls on outflow makes no attempt to empirically examine the importance of stricter regulations and enforcement for the effectiveness of capital controls. In our assessment of the capital controls in Iceland, we attempt to address this void in the empirical literature by analyzing the effect stronger enforcement and more comprehensive capital controls have on the premium you pay for evading the controls in the off-shore exchange rate market.

Furthermore, the main advantage of previous studies examining whether capital controls increased monetary policy independence is that they employ rigorous econometric frameworks (GARCH) on daily nominal interest rates. However, the analysis of monetary autonomy is one dimensional and mainly focuses on whether interest rates decrease and stabilize following the introduction of capital controls. In the context of a currency crisis, which is the case of Iceland, the real question of interest is whether monetary policy becomes more autonomous with regards to the exchange rate. In other words, are capital controls effective in decreasing the sensitivity of the exchange rate to domestic interest rates? Even though capital controls can give room for lower and more stable interest rates, if the exchange rate is still just as sensitive to interest rate changes post-controls as it was pre-controls, one could claim that capital controls have not, in fact, managed to increase monetary policy independence. In section six, we introduce our models that are intended to address the shortcomings of previous research on capital controls on outflow.

3. The Case of Iceland

In October 2008, Iceland got into the worldwide news as it was hit with a severe systemic crisis following the collapse of its three major banks. The collapse was, indeed, related to the global financial crisis. However, to understand the particular case of Iceland it is important to point out the unique set of circumstances in the country. These include factors such as an extensive inflow of foreign capital due to high interest rates, a banking system that had grown out of proportion in relation to the size of the economy as a whole, rapid credit expansion, widespread inflation indexation,[5] and borrowing in foreign currencies (CBI, 2010d).

As the economy was booming in the years leading up to the crisis, the macroeconomic imbalances grew extreme and monetary policy alone could not contain them. Tighter monetary policy with higher interest rates attracted carry traders, who were eager to exploit the high interest rate differential compared to the low interest rate environment in many other countries around the same time. The large volume of capital that flowed into the country in 2005-2008 came in many forms; some came through conventional financial investments and others through instruments specially constructed to benefit from the combination of wide interest rate differentials and an appreciating currency, such as glacier bonds.[6] The inflow of money led to an unsustainable appreciation of the ISK, which in turn contributed to increased consumption and a large trade deficit in the short-run (CBI, 2010d).[7] ISK holdings of non-residents were estimated at roughly ISK 600 billion (40 percent of GDP) in the spring of 2009. Thereof, roughly ISK 250 bn were estimated to be owned by investors who most likely wanted to exit the Icelandic market at the earliest opportunity (CBI, 2009).

The balance sheets of the three largest banks in Iceland, Kaupthing, Landsbanki and Glitnir, grew enormously; in 5 years, between 2003 and September 2008, the assets of the banking system grew from being twice the size of GDP to more than fourteen times the GDP of Iceland (see *figure 1*) (CBI, 2010d). The growth of the banking system was mostly due to expansion abroad, as the Icelandic market evidently is quite limited by its size of only 320,000 inhabitants (CBI, 2010d). The external growth brought about new ways of conducting business, one of which was Icesave.[8]

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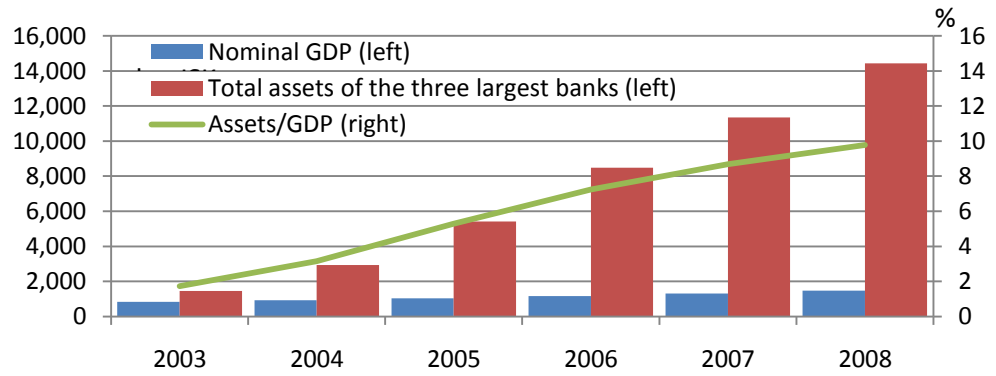
[5] Inflation indexed bonds have a principal that is subject to inflation and rises according to a price index such as a consumer price index. These bonds are designed to cut out the inflation risk of an investment and were introduced in Iceland over 50 years ago as a response to high and persistent inflation.

[6] Glacier bonds are Eurobond issues in ISK, i.e. bonds that are issued in a currency other than the currency of the country or market in which they are issued.

[7] The FX inflow enabled residents to avoid CBI's high interest rates, i.e. it shifted the domestic borrowing towards foreign interest rates. Thus, the effectiveness of monetary policy was greatly reduced as the monetary transmission mechanism was weakened.

[8] Icesave was an online retail savings account, operated by a branch of Landsbanki in the United Kingdom and the Netherlands, which later became the root of a long and winding dispute, which is still unsolved, about how to deal with the deposit insurance of those accounts, following the collapse of Landsbanki.

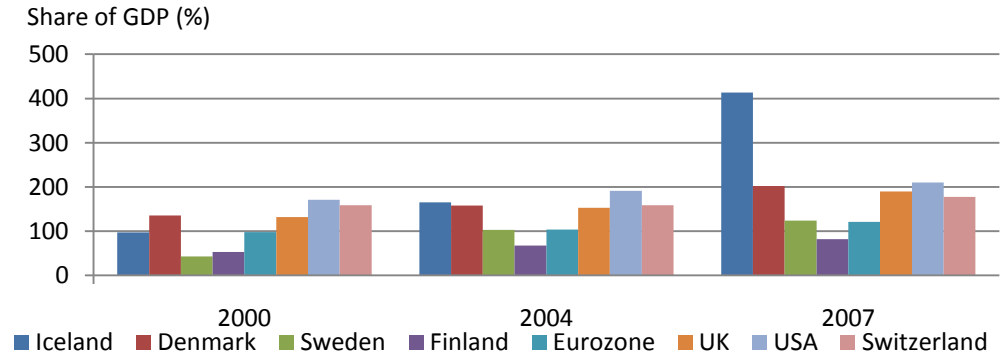
Figure 1: **Total assets of the three largest banks as a share GDP, 2003-2008**



Source: Statistics Iceland, Central Bank of Iceland
Note: End-year figures, except for 2008, for which the numbers are from mid-year.

Leading up to the financial crisis, companies and household in Iceland became increasingly leveraged; private sector debt rose from around 100 percent of GDP in 2000 to over 400 percent of GDP in 2007. At the beginning of 2000, the debt level was similar to the levels in the neighboring countries, but after 2004, the debt of Icelandic corporations and households skyrocketed (see *figure 2*). The gigantic growth in debt was triggered by both supply and demand factors, such as the large inflow of money into the economy, unrealistic optimism about future growth prospects, and restructuring in the mortgage borrowing market in 2004.[9] In addition to the fact that private sector balance sheets were highly leveraged in international comparison, a large proportion of the debt was foreign currency-denominated and inflation-indexed, which in turn meant a large exposure to currency risk (CBI, 2010d).

Figure 2: **Country comparison: Private sector debt for the years 2000, 2004, and 2007**



Source: Reuters Ecowin, Central Bank of Iceland

The sub-prime crisis and all the risk aversion and turbulence that followed, together with all the above mentioned imbalances in the Icelandic economy, led to the sequence of events that in the fall of 2008 triggered the collapse of the three largest Icelandic banks. The collapse of the banking system was an enormous hit for the economy, and the loss of confidence in the Icelandic economy

[9] It should, however, be mentioned that a few large asset holding companies with extensive foreign activities explain a large share of the increase in private sector debt (CBI, 2010d).

threatened to trigger large capital outflows and further depreciation of the ISK. Extensive capital flight would have generated an even more severe wave of bankruptcies of both households and companies due to the previously mentioned high leverage and exposure to foreign exchange risk. As a result of this serious threat, the CBI resorted to capital controls on outflow (CBI, 2010d).

In the absence of capital controls, there was a risk that a vicious cycle could develop; a cycle where large currency depreciation could lead to a wave of domestic bankruptcy, social and political instability, elevated inflation, and rising risk premium, which then again could trigger further depreciation of the currency and another round of this dismal development. Furthermore, the capital controls gave room for a more lax fiscal adjustment because in their absence, financing of fiscal debt would have been more difficult and the interest payments involved higher. Thus, the chief purpose of the capital controls was to avoid extensive outflow of capital and prevent a vicious cycle of further depreciation of the ISK. This was in turn intended to give room for more independent fiscal and monetary policy, lower inflation, and limit the effects on balance sheets of households and companies that were sensitive to exchange rate fluctuations and inflation (CBI, 2010b).

Capital controls came initially into effect on October 10th, 2008, when the Central Bank issued guidelines for financial institutions concerning limitations on the sale of foreign currencies (CBI, 2008). However, capital controls were not formally introduced into the law until November 28th, 2008 (Althingi, 2011). Since then, several revisions aimed at making the controls more comprehensive and enforcing them more strongly have been made (see *table 1*).

According to the Act on Foreign Exchange and the subsequent Rules on Foreign Exchange, most capital transactions are controlled both for residents and non-residents, i.e. the ability to shift between ISK and foreign currencies as well as transactions between residents and non-residents are restricted. However, payments linked to current account transactions (import and export of goods and services and interest payments) and inward FDI (since November 2009) are exempt from the capital restrictions. ISK denominated bonds and other similar instruments cannot be converted to foreign currency upon maturity, i.e. the proceeds must be reinvested in other ISK instruments. However, interest payments in connection to ISK denominated instrument can be converted into other currencies within a specific time limit (CBI, 2010c). Furthermore, once the capital controls came into law, residents were required to repatriate all foreign currency that they acquire (Althingi, 2011).[10]

[10] Ostry et al. (2011) highlight the importance of residents' repatriation of foreign exchange to be incorporated into capital controls in order to prevent circumvention via transactions between residents and nonresidents abroad.

Table 1: Capital Controls: Key Events

Date	Event
10-Oct-08	The CBI issues guidelines for financial institutions concerning limitations on the sale of foreign currency; temporary restrictions on foreign currency trading and movement of capital between Iceland and other countries are put in place
15-Oct-08	The CBI sets up a daily auction market that should function as temporary foreign exchange arrangements.
28-Nov-08	Capital controls are formally introduced into the law, and the main change from the previously issued guidelines was the additional requirement of repatriation of foreign currency acquired by residents.
31-Mar-09	Amendments to the Foreign Exchange Act; exports of goods and services shall take place in foreign currency.
10-Jul-09	Amendments to the Foreign Exchange Act, which expanded FSA's investigative authority and included penalty provisions for unauthorized intermediation of FX transactions.
31-Oct-09	Amendments to the Foreign Exchange Act; it is stated unequivocally that the unilateral importation of offshore ISK is prohibited. At the same time, the first stage of capital account liberalization was taken, lifting restrictions of outflow of foreign direct investment made after November 1st, 2009.
30-Apr-10	Amendments to the Foreign Exchange Act; the rules on foreign exchange are clarified, the maximum amount of foreign currency that can be purchased for travel is reduced, and specified exemptions are changed in order to remove all doubt about the legality of off-shore transactions.
14-Jun-10	Amendments to the Foreign Exchange Act and the Customs Act assigning the CBI sole jurisdiction over investigations and fines in connection with surveillance of the Act and Rules on Foreign Exchange. Furthermore, investigative authority of the CBI was expanded even further.

Source: CBI (2008-2011), IMF (2008).

Furthermore, the effectiveness of capital controls on outflow has proven to decrease the longer they remain in place (Buiter, 2009; Edwards, 1999; Ariyoshi et al., 2000). Edwards (1999) argues that a major drawback of controls on outflow is that, in many cases, they "become a permanent feature of the country's incentive structure" (p.82) rather than being used as a temporary tool to get through a crisis situation. Even after the original purpose has ended, capital controls can, just like any other type of regulation, develop their own constituencies and thus, become difficult to phase out (Neely, 1999). In the case of Iceland, it has already taken much longer than originally estimated to create the conditions required to lift the capital controls, and earlier this year, the laws that allow for the capital controls were extended to the end of the year 2015.[11] The Icelandic Minister of Economic Affairs has announced that this timeframe, to keep the controls until year-end 2015, is the latest possible date, and the CBI has emphasized that as soon as conditions are favorable enough steps will be taken towards liberalization (MP banki, 2011).

[11] Previously they were to expire on August 31st, 2011.

4. Research Hypotheses

To be able to assess the effectiveness of Icelandic capital controls in reaching their intended objectives, it is essential to define what kind of changes in economic variables would reflect the intended effects of the implementation of capital controls. In our analysis, we will focus on testing the following four specific research hypotheses related to the effectiveness of Icelandic capital controls:

Hypothesis 1: ***Effective capital controls will reduce the outflow of capital from Iceland.***

If controls effectively prevent investors from disposing of their ISK denominated assets and moving their capital abroad, capital outflow from Iceland should decrease in the capital control period compared to the pre-control era.

Hypothesis 2a: ***Effective capital controls will prevent further depreciation of the Icelandic krona.***

Hypothesis 2b: ***Effective capital controls will reduce exchange rate volatility.***

Since capital outflow is one of the main sources of supply pressures on the domestic currency, it can cause the ISK to depreciate. Thus, the decreased supply of ISK in the foreign exchange market due to capital controls should lead to a more stabilized (i.e. a decline in the exchange rate volatility) and a stronger (less depreciated) currency than otherwise would be the case (Kamil & Clements, 2009; Coelho & Gallagher, 2010).

Hypothesis 3: ***Effective capital controls will increase monetary policy independence.***

By introducing capital controls in the event of a financial crisis, there should be less need for monetary authorities to maintain high interest rates in order to prevent capital outflow and the accompanied depreciation of the domestic currency (Edison & Reinhart, 2001b). Thus, if capital controls effectively increase monetary autonomy, we would expect the level of the exchange to be less sensitive to interest rate changes (Coelho & Gallagher, 2010). Furthermore, since capital flows are restricted and thus less responsive to turbulence in international markets, the transmission and influence of global economic shocks to the domestic economy and its economic variables should decrease (Edison & Reinhart, 2001b; Coelho & Gallagher, 2010).

Hypothesis 4: ***Amendments to the capital controls that are aimed at stronger enforcement and intended to make the controls more comprehensive should cause capital controls on outflow to be more effective and thus, increase the exchange rate wedge.***

One of the reasons capital controls on outflow can be ineffective is that regulations are not comprehensive enough and/or not sufficiently enforced; loopholes in the legislation are used by investor to circumvent the controls (Ariyoshi et al., 2000; Buiter, 2009; Ostry et al., 2011). In Iceland,

the main channel through which investors have evaded the controls is the unofficial off-shore foreign exchange market, which mainly arose due to the implementation of capital controls (CBI, 2011). The EURISK exchange rate has been consistently higher (i.e. the ISK weaker) on the off-shore market than on the on-shore market. The wedge between off- and on-shore exchange rates could partly be interpreted as the risk premium you have to pay in order to evade the controls and risk being caught and punished. If capital controls are made more comprehensive and enforced more strongly, the effectiveness of the controls should increase by making it more difficult and costly to trade on the off-shore market. Thus, an increased risk premium for evading the controls should cause the exchange rate wedge to widen.

5. Descriptive Statistics

By employing descriptive statistics, we can analyze how capital flows, exchange rates, and interest rates have changed in the post-control era compared to the period leading up to the capital controls.

5.1 Capital Flows

The capital and financial account of a country's balance of payments capture capital flows between residents and non-residents. By studying *figures 3* and *4*, one can see that Icelandic quarterly capital flows as a percentage of GDP have fluctuated considerably over time.

***Figure 3*: Net capital and financial account (% of GDP)**

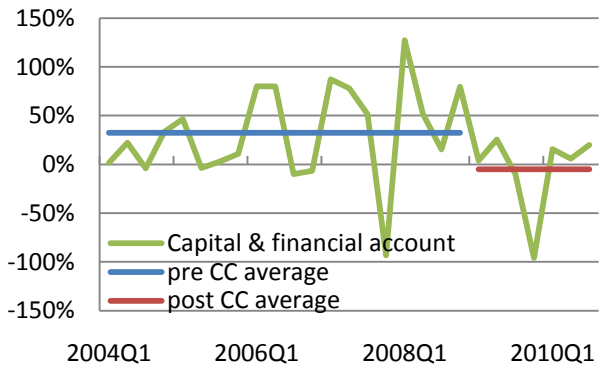
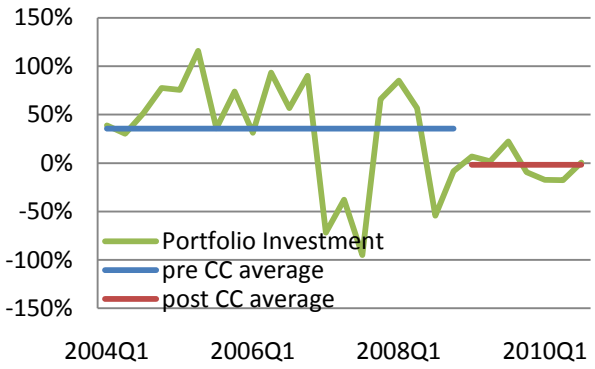


***Figure 4*: Net portfolio investment (% of GDP)**



Source: Central Bank of Iceland and author's adjustments

The portfolio investments category is of particular interest since it mainly consists of liquid assets that investors could sell quickly in order to exit the market.[12] Thus, this category of capital flows includes some of the asset classes that are likely to be the first ones to leave Iceland in a case of capital flight. As can be seen in *figure 4*, net portfolio investments dropped to close to zero after the capital control implementation, and volatility also decreased significantly (see *table 2*). Since the drop in portfolio investment is a net change, and furthermore, it is highly likely that inflow of portfolio investment decreased sharply to very low levels following the banking collapse, it appears that there has not been any extensive outflow of capital in this category. If large volume of capital would have left Iceland at the same time as capital inflow more or less came to a halt because of the crisis, net portfolio flows is likely to have been negative. Thus, based solely on descriptive statistics alone, it appears as if capital control might have been successful in preventing an extensive outflow of portfolio investments.

Furthermore, non-residents' ISK holdings were estimated by the Central Bank to be about ISK 465 bn at the beginning of 2011 compared to previously mentioned position of roughly ISK 600 bn in the spring of 2009. The decrease in the position over time can mostly be explained by the CBI's buy-back

[12] Portfolio investment captures net purchase of foreign securities (assets) by residents and net investment of non-residents in domestic securities (liabilities) (IMF, 1993). See further details in *appendix B.*

of ISK denominated assets from Avens B.V.[13] in the spring of 2010 (CBI, 2010a). A rough estimate of the characteristics of ISK asset owners indicates that 65-75 percent of them (equaling ISK 155-185 bn) might want to exit as soon as possible (CBI, 2011). The fact that these impatient investors, which represent one of the investor groups that the capital controls were targeted at, are still locked in with their ISK assets indicates that the capital controls might have been successful in hampering otherwise expected capital flight.

***Table 2*: Descriptive Statistics for Capital Flows (Quarterly data: 1Q 2004 – 3Q 2010)**

as % of GDP	Mean (pre CC)	Mean (post CC)	Equality in means t-test (probability)	St.dev. (pre CC)	St.dev. (post CC)	Equality in variance test (probability)
Capital and financial account	0,3253	-0,0501	0,0848*	0,4935	0,4175	0,6340
Capital account	-0,0011	-0,0007	0,1996	0,0008	0,0004	0,0400**
Financial account	0,3249	-0,0494	0,0863*	0,4947	0,4173	0,6280
Foreign Direct Investment	-0,0629	-0,1089	0,8352	0,5236	0,4074	0,4820
Portfolio Investment	0,3558	-0,0185	0,1131	0,5899	0,1430	0,0020***
Other Investment	0,0818	10,216	0,0013***	0,5780	0,6223	0,8260

Source: Authors' estimates, data from Central Bank of Iceland

*Note: The numbers have been corrected so that they exclude transactions related to the old banks' defaults in the post capital control period (see section 7 for further details). Asterisks, ***, **, and *, denote statistically significance of coefficients at the 1%, 5%, and 10% levels, respectively.*

5.2 Exchange rate

Before the banking collapse in the autumn of 2008, the ISK had already depreciated by 40 percent since the beginning of the year. During this time, the global financial crisis had escalated, the Icelandic banks and government were repeatedly downgraded by investment grading companies, and Iceland lost access to foreign liquidity in the first half of 2008. Right after the banking collapse, daily volatility in the ISK was gigantic as the risk aversion and uncertainty soared (CBI, 2010d).

Descriptive statistics of the ISK (see *table 3*) in the official exchange market show that the currency was, on average, almost 45 percent weaker in the period when capital controls were in place compared to the three years leading up to the capital controls. On the other hand, volatility decreased by roughly a third after the implementation of the capital restrictions. The decreased volatility of the ISK could indicate that the capital controls were successful in stabilizing the currency, while the support for an appreciated (less depreciated) currency is not as clear.

[13] Avens B.V. was a Dutch financial vehicle set up by Landsbanki (Central Banking, 2010).

Table 3: Descriptive Statistics for Exchange Rates (Daily data: Jan 1st, 2006 – Dec 31st, 2010)

	Mean (pre CC)	Mean (post CC)	Equality in means t-test (probability)	St.dev. (pre CC)	St.dev. (post CC)	Equality in variance test (probability)
EURISK on-shore exchange rate	99.028	167.249	0.00***	21.053	12.797	0.00***
Changes in on-shore exchange rate (daily %)	0.149	-0.055	0.08*	2.280	1.649	0.00***
EURISK off-shore exchange rate	104.075	236.722	0.00***	40.359	30.419	0.00***
Changes in off-shore exchange rate (daily %)	0.297	-0.065	0.46	5.635	11.334	0.00***

Source: Authors' estimates, data from Central Bank of Iceland, Bloomberg
*Note: Asterisks, ***, **, and *, denote statistically significance of coefficients at the 1%, 5%, and 10% levels, respectively.*

5.3 Monetary policy independence

The Central Bank´s policy rate (repo rate) peaked in the fall of 2008 as it was raised to 18 percent following the banking collapse. A sharp increase in the policy rate from 12 percent to 18 percent was made on October 28th, 2008, in an attempt to defend the ISK from further depreciation (CBI).[14] The interbank interest rates (REIBOR) followed and were also at its highest level at the end of 2008 (see *figure 6*). Since then, policy rates have been lowered substantially and they have, when this is written, been lowered down to 4.25 percent, which are the lowest nominal rates on record (CBI). Despite this steep fall in interest rates, which also is apparent in the data (see *figure 6*), it is difficult to say if capital controls have directly or indirectly decreased the sensitivity of exchange rate to changes in interest rates without conducting any further analysis.

Figure 5: Domestic interest rates (3M REIBOR)

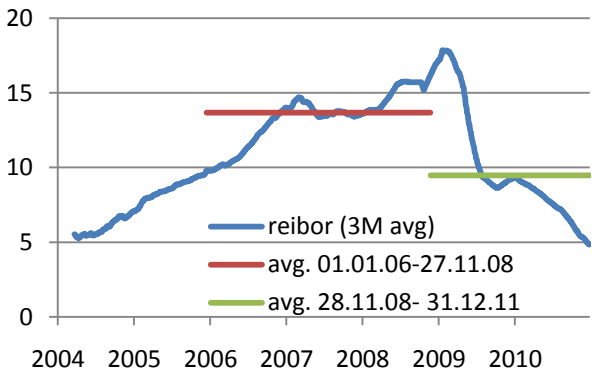
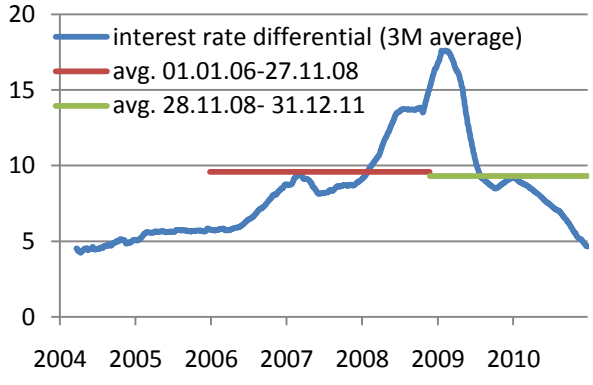


Figure 6: Domestic-foreign interest rate differential



Source: Central Bank of Iceland, U.S. Fed

[14] The repo rate was 12% only for 9 days. Prior to that, the rate was 15.5% (April 10th to October 14th 2008) (CBI).

The descriptive statistics in *table 4* show that the domestic-foreign interest rate differential was, on average, almost the same during the three year period leading up to the capital controls as in the post-control era. However, the trend was drastically different (see *figure 6*). The averages in daily changes tell a completely different story compared to the mean; the pre-capital controls ear was characterized by desperate attempts to curb an overheating economy (i.e. positive interest rate changes, on average) while the post capital controls period was mostly colored by interest rates cuts (i.e. negative interest rate changes, on average). Foreign interest rates were also being lowered as a response to the global financial crisis. However, the foreign interest rate cuts were relatively smaller compared to the Icelandic cuts (the interest rate differentia decreased) since the starting level of foreign interest rates was not as high as in the case of Iceland.

***Table 4*: Descriptive Statistics for Interest Rates (Daily data: Jan 1st, 2006 - Dec 31st, 2010)**

	Mean (pre CC)	Mean (post CC)	Equality in means t-test (probability)	St.dev. (pre CC)	St.dev. (post CC)	Equality in variance test (probability)
Central Bank´s Repo rates (REPO)	13.380	10.985	0.00***	1.720	3.927	0.00***
Domestic interbank interest rates (REIBOR)	13.675	9.475	0.00***	1.849	3.839	0.00***
Daily changes in domestic interbank interest rates (Δ REIBOR)	0.012	-0.026	0.11	0.454	0.355	0.23
US Fed´s interest rates (USint)	4.085	0.169	0.00***	1.472	0.045	0.00***
Daily changes in US Fed´s interest rates (Δ USint)	-0.005	-0.001	0.53	0.149	0.018	0.00***
Domestic vs foreign interest rate spread (O/N)	9.591	9.306	0.14	2.966	3.837	0.38
Daily changes in domestic vs foreign interest rate spread (Δ O/N)	0.017	-0.025	0.09*	0.485	0.353	0.47

Source: Authors' estimates, data from Central Bank of Iceland, U.S. Fed

*Note: Asterisks, ***, **, and *, denote statistically significance of coefficients at the 1%, 5%, and 10% levels, respectively.*

5.4 Exchange rate wedge

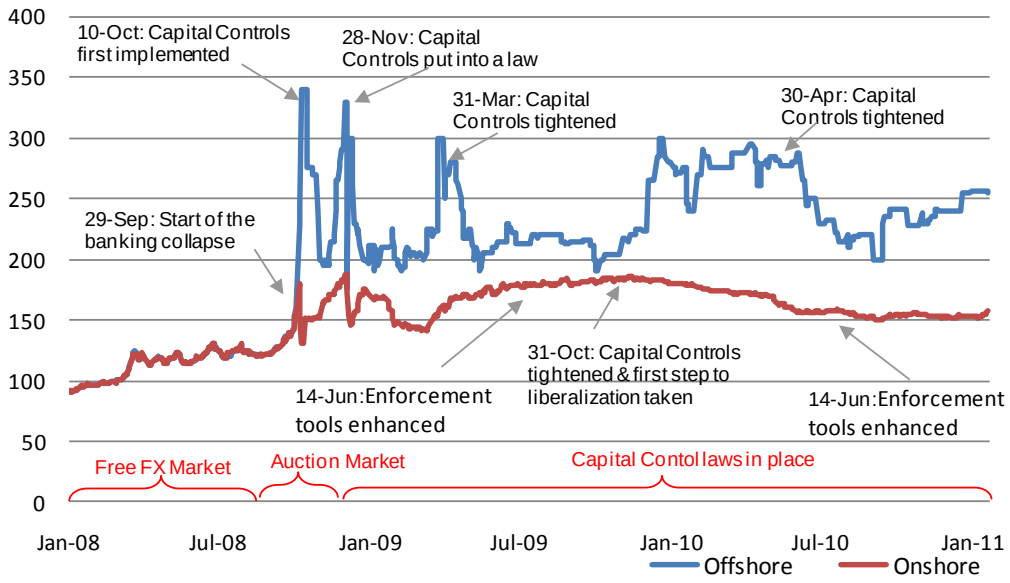
When normal trading was disrupted in the official exchange market, trading started on a so-called off-shore market; an informal market for the ISK that circumvented the capital controls.[15] The off-shore market was the primary channel for circumvention until the capital controls were revised in

[15] Trading initially started on the off-shore market when the CBI operated the FX auction market and continued when the capital controls were put in place. Further note that trading between non-residents is not prohibited. Thus, if residents do not partake in the off-shore trading it is legal.

October 2009, and the off-shore market trading had until then greatly undermined the foreign currency repatriation requirement (CBI, 2011). The exchange rate of the ISK was much weaker on the off-shore market compared to the official on-shore market where the capital controls applied (see *figure 7*). Part of the wedge between the off- and on-shore exchange rate can likely be attributed to the fact that traders in the off-shore market demand a premium on the price they charge because of the risk of being caught and punished for trading against regulations.[16] Furthermore, it could be argued that in the absence of the capital controls, the official exchange rate would lie somewhere between the on- and off-shore exchange rate. In fact, a rough estimate based on CBI's macroeconomic model indicates that the EURISK exchange rate could easily have dropped to 260-300[17] and even further if the controls would not have been in place (CBI, 2010b). If the CBI's analysis is correct, it could indicate that capital controls have, in fact, contributed to a less depreciated currency.

Another point of interest is whether the tightening of regulations to make capital restrictions more comprehensive and more difficult to evade proved to increase the effectiveness of the controls by increasing the wedge between the off- and on-shore exchange rates. By simply looking at *figure 7* below, it appears as if the tightening of controls on October 31st, 2009, increased the exchange rate wedge the most.

***Figure 7*: The ISK exchange rate markets against the Euro**



Source: Central Bank of Iceland, Bloomberg
Note: More detailed explanations of event can be found in appendix A

[16] According to the rules on foreign exchange, internal trading in offshore krónur among non-residents is permitted, while the rules restrict capital transactions between residents and non-residents (CBI, 2011).
[17] This is close to what the off-shore exchange rate was at its lowest following the collapse of the banking system.

Although descriptive statistics provide an aggregate summary of changes in the variables of interest in the pre-control era compared to the post-control era, they do not take into account any domestic or external factors that could possibly influence the variables. Thus, we proceed to further conduct a formal econometric analysis of capital controls based on recognized empirical methods.

6. Empirical Model

The following sections focus on the empirical models applied when addressing the questions of how successful capital controls have been in (1) decreasing capital outflows, (2) stabilizing the exchange rate, (3) increasing monetary policy independence, and (4) increasing the exchange rate wedge. Statistical tests of the models and sources for the variables can be found in *appendix D* and *E*, respectively.

6.1 Model 1 - Capital outflow

To investigate whether capital controls decreased outflows, we employ a panel fixed effect model inspired by Binici et al. (2009), Montiel and Reinhart (1999), and Coelho and Gallagher (2010). By using a panel fixed effect model, we can control for domestic and external factors influencing cross-border capital flows. The panel fixed effect model compares sub-categories of net capital flows in Iceland to the EU-15 countries,[18] which were also affected by the financial crises but did not implement capital controls. We use a cross-country data set of quarterly capital flows drawn from the Balance of Payments and analyze five categories of capital flows: capital account, financial account, portfolio flows, FDI, and capital and financial account combined.[19] The following panel fixed effect regression is estimated for each of the five capital flow categories from Q1 2007 until Q3 2010:

$$Flow_{it} = \beta_0 + \beta_1 CurrAcc_{it} + \beta_2 Country_i + \beta_3 Quarter_t + \beta_4 DCC_{it} + \varepsilon_t \quad (1)$$

Where $Flow$ is a category of net capital flows as a percentage of GDP; $CurrAcc$ is the current account balance as a percentage of GDP; $Country$ is a country specific fixed effect dummy; $Quarter$ is a quarter specific fixed effect dummy; DCC is a binary dummy for capital controls; ε is the normally distributed error term; and i and t denote country and quarter, respectively.

Regarding the set of control variables, the current account balance is included because previous research has shown that it is a significant explanatory variable of capital flows (Coelho & Gallagher, 2010).[20] The country fixed effect dummy is supposed to capture any country specific omitted variables that are relatively stable over the time period covered and could impact capital flows. In addition, a quarter dummy is included to capture any unobservable factors that impact the overall

[18] Belgium is excluded due to lack of data.

[19] The IMF divides the balance of payments into three categories: current account, capital account and financial account (IMF, 1993). For further explanation of the categories of capital flows, see *appendix B*.

[20] Ideally, we would have liked to control for country specific short-term interest rates and their effect on capital flows. However, it was troublesome to obtain a comparable set of interest rates for all the countries in the sample. While interest rates on long term government bonds were available, they turned out to be highly insignificant and hence dropped from the fixed effect regression.

trend of capital flows.[21] The capital control dummy takes on the value of one if the capital restrictions were in effect during the majority of the quarter; otherwise, the dummy take on the value of zero.[22] Finally, because statistical test find evidence of heteroskedasticity in our sample, the regressions are estimated using robust standard errors.

To answer the question of how successful capital controls were in decreasing outflows, the variable of interest is the coefficient on the capital control dummy, β_4. If the coefficient is positive and statistically significant, Icelandic capital restrictions increased net capital flows during the control period compared to other European countries who did not implement such restrictions. Given the fact that capital inflow to Iceland is not likely to have increased during the crisis period, an increase in net capital flows would therefore most likely be due to a decrease in outflows.

6.2 Model 2 - Exchange rates

To analyze if capital controls achieved the goal of a more stable and less depreciated exchange rate, we use a GARCH model based on Kamil and Clements (2009).[23] One stylized fact documented by empirical research on daily exchange rates is that they exhibit conditional heteroskedasticity (i.e. volatility clustering) with long term persistence in the conditional variance (Kiliç, 2007). Therefore, the GARCH model, which explicitly models the non-constant variance, has become the standard empirical method in research by which the process underlying exchange rate volatility is modeled.[24] While controlling for various daily determinants of the exchange rate, the GARCH model uses log likelihood to estimate the effects of controls on the level and volatility of daily nominal exchange rates. The GARCH model is estimated from January 1st, 2006 until December 31st, 2010 and has the following specifications:[25]

$$\Delta(\ln s_t) = \beta_0 + \beta_1\Delta(\ln s_{t-1}) + \beta_2 INT_t + \beta_3\Delta(i-r)_t + \beta_4 VIX_t + \beta_5 CDS_t + \beta_6\Delta Comm_t + \beta_7 DCC_t + \varepsilon_t \quad (2)$$

$$\varepsilon_t|\Omega_{t-1} \sim N(0, \sigma_t^2) \quad (3)$$

$$\sigma_t^2 = \alpha_0 + \alpha_1\sigma_{t-1}^2 + \alpha_2\varepsilon_{t-1}^2 + \alpha_3 INT_t + \alpha_4|\Delta(i-r)_t| + \alpha_5 VIX_t + \alpha_6 CDS_t + \alpha_7|\Delta Comm_t| + \alpha_8 DCC_t + v_t \quad (4)$$

[21] However, standard statistical tests indicated presence of time fixed effects only in the regression of the capital account. Thus, the quarter specific fixed effect dummy is dropped from the regressions with the other capital flow categories.
[22] For Iceland, the capital controls dummy covers Q4 2008 to Q3 2010.
[23] Specifically, a GARCH (1,1) model is used.
[24] See *appendix C* for a detailed explanation of the GARCH model.
[25] The model is estimated starting January 1st, 2006, in order to capture a considerable period of relatively calm and stable foreign exchange markets prior to the introduction of capital controls.

Where $\Delta(\ln s)$ is the daily percentage change in the official EURISK nominal exchange rate and enters the equation in first difference of the natural log (i.e. a negative change equals an appreciation of the ISK);[26] INT is the CBI's interventions (volume) in the foreign exchange market, in ISK per day; $\Delta(i-r)$ is the daily percentage change of the interest rate spread between Reykjavik Interbank Offered Rate (REBOIR) and the U.S. Federal funds rate;[27] VIX is the Chicago Board Options Exchange Market Volatility Index and measures the implied volatility of the U.S. stock market (S&P 500 index); CDS is the daily Credit Default Swap (CDS) spread on obligations of the Icelandic government, in basis points per year; $\Delta Comm$ is the daily percentage change in world aluminum prices; and DCC is a binary dummy for capital controls. The dummy equals zero before capital controls were put in place on October 10th, 2008, and takes on the value of one thereinafter. Finally, $|\ |$ is the absolute term operator, and ε is the normally distributed error term with zero mean and variance σ^2; that is, σ^2 is the conditional variance that controls for the lagged variance, lagged error terms squared, and the explanatory variables from equation 2.

To analyze the effect of capital controls on the exchange rate, the main variable of interest is the capital controls dummy in the mean equation (equation 2) and in the variance equation (equation 4). In the GARCH model, the mean equation analyzes the determinants of the exchange rate *level* while the variance equation examines the determinants of the exchange rate *volatility*. If capital controls led to less a depreciated (more appreciated) exchange rate, the coefficient on the control dummy in the mean equation, β_7 should be negative and statistically significant. In the variance equation, if capital controls stabilized the exchange rate (i.e. decreased volatility), the coefficient on the control dummy, α_8, should be negative and statistically significant. Thus, we would expect capital controls to have reached their goal of a more stable and less depreciated exchange rate if coefficients on both controls dummies in the GARCH model, β_7 and α_8, are negative and statistically significant.

The estimated model controls for several variables that affect short-term exchange rate movements through demand and supply pressures. The CBI's interventions are included because the CBI could possibly affect both the exchange rate level and volatility by participating in the foreign exchange market. The model also controls for domestic-foreign interest rate differential, which is included to capture the potential effect of monetary policy and local money market conditions on exchange rate movements. If the interest rate spread widens, foreign capital is likely to flow into the country (or less likely to flow out), thereby increasing the demand for the domestic currency and causing the ISK to appreciate. Furthermore, the volatility of the U.S. stock market, the VIX index, is supposed to be a proxy for global risk sentiment and capture the impact of investors' perception of global financial risk

[26] $\Delta(\ln s) = \ln(s_t) - \ln(s_{t-1})$

[27] The fed funds rate are the US interbank rates and thus comparable to the REIBOR interbank rates (Federal Reserve Bank of New York, 2011).

on the exchange rate. We believe this variable to be relevant since the volatility in the Icelandic foreign exchange market depends, to some extent, on the volatility in international markets. The credit default swap (CDS) spread is included to reflect the market's anticipation of the likelihood of default of the Icelandic government and is a proxy for country risk.[28] The market's evaluation of the Icelandic government's ability to fulfill all of its commitment is likely to be a determinant of investors' demand for domestic currency. Finally, the commodity price index of aluminum aims to capture the impact of current account developments on the exchange rate. Since aluminum is Iceland's largest single export commodity, the variable is intended to be an indicator of Iceland's terms of trade on a daily basis and its associated effect on the demand and supply pressures on the exchange rate.[29]

6.3 Model 3 - Monetary policy independence

To analyze if Icelandic capital controls increased monetary policy independence and reduced the transmission of global economic shocks to the Icelandic economy, we augment the GARCH model on daily nominal exchange rates to include two interaction terms as explanatory variables. The method is inspired by Coelho and Gallagher (2010). The model has the following specifications:

$$\Delta(\ln s_t) = \beta_0 + \beta_1 \Delta(\ln s_{t-1}) + \beta_2 INT_t + \beta_3 VIX_t + \beta_4 CDS_t + \beta_5 \Delta Comm_t + \beta_6 DCC_t + \beta_7 \Delta i_t + \beta_8 \Delta r_t + \beta_9 DCC_t * \Delta i_t + \beta_{10} DCC_t * VIX_t + \varepsilon_t \quad (5)$$

$$\varepsilon_t | \Omega_{t-1} \sim N(0, \sigma_t^2) \quad (6)$$

$$\sigma_t^2 = \alpha_0 + \alpha_1 \sigma_{t-1}^2 + \alpha_2 \varepsilon_{t-1}^2 + \alpha_3 INT_t + \alpha_4 VIX_t + \alpha_5 CDS_t + \alpha_6 |\Delta Comm_t| + \alpha_7 DCC_t + \alpha_8 |\Delta i_t| + \alpha_9 |\Delta r_t| + \alpha_{10} DCC_t * |\Delta i_t| + \alpha_{11} DCC_t * VIX_t + v_t \quad (7)$$

Where Δi is the daily change in the domestic interest rates (REIBOR); Δr is the daily change in foreign interest rates (the U.S. Federal funds rate); $DCC * \Delta i$ is the capital controls dummy multiplied by the daily change in the domestic interest rates; $DCC * VIX$ is the capital controls dummy multiplied by the implied volatility of the U.S. stock market; and all the remaining variables are defined as in the previous section. The model is estimated from January 1st, 2006, to December 31st, 2011.

[28] It should be noted, however, that the CDS spread has been much less traded in the post control period than before the controls, which could lead to a less active price formation. This is due to the fact that the Treasury of Iceland has a limited outstanding debt that could be insured against default.

[29] The coefficient for Comm should be interpreted with cautions as daily fluctuations in aluminium prices can be substantial and not all aluminium export is likely to be sold at spot prices but rather at a pre-contracted prices.

The variables of interest are the coefficients on the two interaction terms in the GARCH mean equation (5), namely β_9 and β_{10}. The coefficient on the interaction term of the domestic interest rate and the capital controls dummy, β_9, is suppose to capture monetary policy independence measured as the sensitivity of the exchange rate to differences in the domestic interest rate under capital controls. If monetary policy independence increased in the control period, the CBI should be able to decrease the interest rate without causing the exchange rate to depreciate (or at least depreciate less than if controls were *not* in place). Thus, β_9, should be positive and statistically significant.

With regards to the coefficient on the interaction term of the capital controls dummy and the implied volatility of the U.S. stock market, β_{10}, it is suppose to capture the sensitivity of exchange rates to global financial turmoil. If capital controls were able to reduce the transmission of global financial shocks to Iceland, the exchange rate should be less sensitive to volatility in international markets post-controls than they were pre-controls; β_{10} should be negative and statistically significant.[30]

6.4 Model 4 - Exchange rate wedge

To address the void in the empirical literature regarding the importance of comprehensive controls and strong enforcement for the effectiveness of capital controls on outflow, we employ an Ordinary Least Squared (OLS) regression on the wedge between off- and on-shore exchange rates while controlling for the six main amendments to the capital control regulations.[31] The OLS model has the following specifications:

$$Wedge_t = \beta_0 + \beta_1(i-r)_t + \beta_2 VIX_t + \beta_3 CDS_t + \beta_4 INT_t + \beta_5 Comm_t + \beta_6 DCC_t + \beta_7 DCC1_t + \beta_8 DCC2_t + \beta_9 DCC3_t + \beta_{10} DCC4_t + \beta_{11} DCC5_t + \beta_{12} DCC6_t + \varepsilon_t \quad (8)$$

Where $Wedge$ is the difference between the off- and on-shore exchange rate, and DCC is a binary dummy for when capital controls were initially put in place. The dummy equals zero before capital controls were implemented on October 10th, 2008, and takes on the value of one thereinafter. Furthermore, $DCC1$ is a dummy for when the capital controls came into law on November 28th, 2008; $DCC2$ is a dummy for the revision on March 31st, 2009; $DCC3$ is a dummy for the revision on July 10th, 2009; $DCC4$ is a dummy for the revision on October 31st, 2009; $DCC5$ is a dummy for the

[30] Adding the interaction terms changes the interpretation of the coefficient on the variable in question depending on if capital controls are in place or not. For example, pre- controls (the dummy is zero), the effect of the domestic interest rates can be interpreted as the coefficient on Δi_t, β_7. However, after controls are in place (dummy equals one), the effect of domestic interest rates equals β_7 plus the coefficient on the interaction term, β_9. The same applies for the VIX index; in the augmented GARCH model, the effect of the VIX index is β_3 pre capital controls compared to (β_3+β_{10}) post capital controls.

[31] See *table 1* for the amendments.

revision on April 30th, 2010; $DCC6$ is a dummy for the revision on June 14th, 2010; and all the remaining variables are defined as previously. The six dummies for the capital controls amendments equal zero before their respective revisions were made and take on the value of one thereinafter.

The set of control variables is chosen to be the same as in the GARCH model on nominal exchange rates since those variables are likely to impact the wedge though demand and supply pressures on the on-shore exchange rate and, to a certain extent, the off-shore exchange rate as well. The variables of interest are the dummies for the revisions of capital controls. If the amendments to the capital control regulations made the capital controls more effective by inducing a premium for trading with ISK in the unofficial off-shore market, the wedge should increase. Thus, the coefficients on the dummies for the revisions, β_7, β_8, β_9, β_{10}, β_{11}, and β_{12}should be positive and statistically significant.

7. Data Adjustments and Empirical Concerns

7.1 Data adjustments

It is evident from Icelandic data that capital flows have fluctuated greatly both on a quarterly and annual basis. In the period after the banking collapse, the fluctuations were exceptionally large and, to a large extent, related to the assets of the banks undergoing winding-up proceedings (CBI, 2010b). In accordance with international standards published by IMF,[32] when debt securities of the defaulted banks matured (i.e. defaults of the banks' debts), they were moved from the portfolio investments liabilities category in the balance of payments to a category called "other investments, liabilities".[33] Such transactions related to the defaulted banks are not a real flow of funds, but rather arise because of accounting procedures. Thus, the raw data for portfolio investment provides a distorted picture of the reality as the transactions related to the defaulted banks are quite sizable in comparison to other capital flows.

We were able to access an unpublished data series for the breakdown of the old banks' share in portfolio investments and other investments, which we used to correct the published data. By adjusting the data, we were able to construct a time series of capital flows less the capital movement related to the winding-up proceedings of the old banks. The adjustment improved our data a great deal; however, there are still several reasons why the data on capital flows needs to be interpreted with caution.

First of all, since the Balance of Payments is reported on a net basis (i.e. net capital flows) and the highest available frequency of data is quarterly, the number of options that can be pursued to analyze the capital flows are quite limited.[34] In order to get the most accurate estimation of actual capital outflow, ideally, we would have like to have access to gross capital flow with higher frequency.

Secondly, the quality of the balance of payments reported in Iceland is, to some extent, questionable as *net errors and omissions* have amounted to as much as half of the total capital account in the last five years (CBI). The size of the net errors and omissions alone could indicate that a substantial part of the actual capital flow is not categorized correctly.

[32] The most resent guidelines are found in the *Balance of payments and international investment position manual 6th edition*, which was published in 2009. (IMF, 2009).
[33] The thought behind this is that the debt securities no longer exist but the debt does – but after maturity it should be registered as other liabilities.
[34] Due to the low frequency of data available, a regular OLS regression of *only* Icelandic capital flows on explanatory variables yields statistically insignificant results.

Furthermore, several large capital transactions that were facilitated and permitted by the CBI have had large effects on capital movements. For example, in the spring of 2010, the CBI purchased ISK denominated assets of around ISK 120 bn from Avens B.V., which was the largest single owner of ISK denominated assets outside Iceland (CBI, 2010a). This transaction alone equaled approximately double the net capital and financial account movements in that quarter and around one-fourth of all ISK denominated assets owned by non-residents. The example above clearly illustrates that all outflow of capital do not necessarily indicate circumvention of the capital controls; thus, the empirical results should be interpreted with caution.

7.3 Empirical Issues

Several other empirical challenges are worth emphasizing with regards to the analysis of capital controls.

First, the empirical analysis in this thesis focuses only on short- and medium-term implications of capital controls on a selected set of variables.[35] The analysis is not intended to identify or yield any predictions regarding the long-run macroeconomic effects of capital controls; such an analysis is beyond the scope of this thesis.

Second, the results of the analysis are episode specific and do not represent any stylized facts (Kamil & Clements, 2009). Since the introduction of capital controls are influenced by external circumstances and economic conditions that are country-specific, the empirical results specifically apply to the case of Iceland, and therefore, we cannot draw any general policy conclusions regarding the effectiveness of capital controls in other settings.

Third, it is widely recognized in the empirical literature that evaluations of the effectiveness of capital controls in reducing outflow tend to suffer from endogeneity due to two-way causality and omitted variables (Magud and Reinhart, 2006). Capital controls are not exogenous to capital flows, but rather implemented by authorities as a response to excessive volumes of cross-border capital flows that can destabilize the economy; thus, it exists a two-way causality relationship between the capital controls and capital flows. Furthermore, structural reforms carried out around the same time as capital controls could possibly affect capital flows (Magud and Reinhart, 2006). However, country specific reforms are difficult to measure and include in the analysis. Thus, in the panel fixed effect model, it is likely that some level of correlation exists between capital controls and omitted variables captured by the error term. The problem of endogeneity can possibly cause estimators to be biased and/or inconsistent. Typically, endogenous explanatory variables are dealt with through instrumental variables (IV) (Wooldridge, 2009). But since the endogenous variable in our case of capital controls is

[35] Our analysis covers roughly the first two years of the capital controls episode that started in October 2008.

a binary dummy, instrumental variable estimation becomes difficult to implement (Angrist, 2001). An important point to make is that endogeneity is, by no means, unique to our analysis but is generally problematic to most empirical literature in the field. Although the problem of endogeneity is frequently recognized by researchers, it is seldom dealt with explicitly. Since the endogeneity of capital controls is difficult to correct, it is important to be aware of the potential problem of inconsistent estimator, and thus, the results should be interpreted with caution.

8. Empirical results

8.1 Model 1 - Capital outflow

Out of the five categories of capital flows analyzed in the panel fixed effect model, only the results from the regression with net capital account flows indicate that capital controls did increase net capital flows (decrease net outflow) in Iceland compared to the set of EU-15 countries who did not implement controls (see *table 5*). The fit of the model (R-squared) is also considerably higher (25.5%) for capital account flow compared to the other categories of capital flows. However, as the capital account is very small in relation to GDP and covers non-financial transactions which were not the *main* targets of the capital controls, one should be careful to draw conclusions regarding the effectiveness of capital controls based solely on these results.

Regarding the four remaining categories of capital flows, the results indicate that the capital controls did not have any significant impact on capital flows in Iceland when compared to the EU-15 countries; the capital control dummies are statistically insignificant. The fact that capital controls do not appear to affect FDI is perhaps not surprising since FDI flow is likely to be motivated by long-term views and governed by various other factors apart from capital controls. However, we would rather have expected to see some increase in net portfolio investment since that subcategory includes short-term investment flows, which the capital controls were especially targeted at. Given the severity of the global economic crisis, the inconclusiveness of the results could possibly be attributed to the volatility of capital flows in international markets during the period in question. Furthermore, our analysis is colored by the fact that we cannot measure gross outflow but have to rely on net capital flow measures.

***Table 5*: Panel fixed effect model with quarterly net capital flows: Q1 2007-Q3 2010**

Dependent Variable	Capital Account	Financial Account	Capital & Financial Account	Portfolio Flows	FDI Flows
Current Account	-0.0301**	-0.5727*	-1.6520	-1.6247	0.3004
	(0.0131)	(0.3375)	1.3865	1.3883	0.6346
Capital Control Dummy	0.0063**	-0.3214	0.2717	0.2676	-0.0540
	(0.0029)	(0.3274)	0.3349	0.3352	0.2070
R-Squared	0.2553	0.0934	0.0019	0.0025	0.0180
No. of observations	225	225	225	225	225

Source: Authors' estimates

Note: The countries in the sample include Austria, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom, and Iceland. All variables, except for the capital controls dummy, are reported as a percentage of GDP. Robust standard errors are reported in parenthesis. Asterisks, ***, **, and *, denote statistically significance of coefficients at the 1%, 5%, and 10% levels respectively.

The results from the fixed effect model are in accordance with findings of previous empirical research, which in most cases has shown that capital controls on outflows have had little success in reducing capital outflows. For example, Ariyoshi et al. (2000) conclude that capital controls have only had a temporary effect in reducing outflows of capital in the cases of Malaysia (1998), Spain (1992), and Thailand (1997). In addition, Edison and Reinhart (2001a) reported similar results.

However, the results from the panel fixed effect model are not entirely in line with the results from the analysis of descriptive statistics in section five. The fact that ISK asset holdings of non-residents have not decreased substantially since the spring of 2009, and that a large part of those holding belong to impatient investors who would have preferred to exit the Icelandic market could indicate that controls on outflow have succeeded in curbing outflows. Although the analysis of descriptive statistics does not rely on rigorous statistical methods, the fact that the fixed effect model yield insignificant results, for the most part, raise concerns regarding its validity. Thus, descriptive statistics appear to provide a more accurate analysis of the effectiveness of Icelandic capital controls in reducing outflow.

In theory, however, there are several reasons why capital controls can fail to curb outflow. The most obvious ones are too lax capital restrictions and/or a lack of enforcement, both of which would lead to leakages and circumventions of the controls. In the case of Iceland, the off-shore market has provided opportunities to profit from skirting the capital controls, which might have made it more difficult for Icelandic authorities to steadfastly eliminate circumventions. After all, as long as there are arbitrage opportunities in the market place, investors are likely to exploit them.

8.2 Model 2 - Exchange rate

One of the key motivations behind the capital controls in Iceland was to stabilize the exchange rate and steer clear of further weakening of the domestic currency. This brings us to the twofold hypothesis regarding the exchange rate, namely if capital controls effectively prevented further depreciation of the Icelandic krona and reduced exchange rate volatility. In order to conduct this part of the analysis, we look at the results from the GARCH model on nominal exchange rates.

The main focus in the GARCH model is on the coefficient on the capital control dummy (DCC) in the mean and variance equation, i.e. the average impact of capital controls on the level and volatility of the exchange rate, respectively. According to our analysis, the introduction of restrictions on capital outflow was effective in supporting the ISK as the coefficient on the capital controls dummy in the mean equation is negative and statistically significant at the ten percent level (a negative change equals an appreciation of the exchange rate). Effects of other explanatory variables on the level of the EURISK exchange rate are either very small or insignificant in the mean equation.

Furthermore, capital controls have been effective in stabilizing the exchange rate as the coefficient on the capital control dummy in the variance equation is negative and statistically significant at the one percent level. All other variables in the variance equation are significant and have the expected sign. The VIX and CDS are proxies for higher risk perception (globally and domestically) and positively affect exchange rate volatility. Changes in the interest rate differential and commodity prices seem to increase exchange rate volatility, which is in line with expectations since higher fluctuations in those variables would increase the supply and/or demand for the ISK currency.[36] An increase in interventions appears to slightly reduce exchange rate volatility, which is in line with expectations since one of the motivations behind the Central Bank's interventions in the foreign exchange market is to meet excessive supply or demand, i.e. counterbalance exchange rate pressures.

***Table 6*: GARCH model with daily nominal exchange rates: Jan 1st, 2006 – Dec 31st, 2010**

Dependent Variable:	**On-shore EURISK**	
	Mean Equation	**Variance Equation**
$\Delta(\ln s_{t-1})$	0.1053***	-
	(-0.0323)	-
INT	0.0000	-0.0022
	(0.0000)	(-0.0013)
$\Delta(i-r)$	-0.0004	0.4955
	(-0.0005)	(-0.4100)
VIX	0.0001*	0.0747***
	(0.0000)	(-0.0118)
CDS	0.0000	0.0014**
	(0.0000)	(-0.0007)
$\Delta Comm$	0.011	68.8658***
	(-0.0141)	(-12.9279)
DCC	-0.0011*	-3.4442***
	(-0.0006)	(-0.3160)
No. of observations	1246	1246

Source: Authors' estimates
*Note: Robust standard errors are reported in parenthesis. Asterisks, ***, **, and *, denote statistically significance of coefficients at the 1%, 5%, and 10% levels, respectively.*

In sum, we find strong support for the hypothesis that capital controls have proven successful in supporting the Icelandic krona and decreased exchange rate volatility. Findings of previous research regarding this goal of the capital controls are mixed. Edison and Reinhart (2001a) conclude that

[36] More changes in the interest rate differential increase the opportunities for carry trade and could attract increased interest of foreign investors, which in turn could affect the FX market. More fluctuations in commotity prices mean that there are also more fluctuations in exporter's supply of foreign currency, which in turn leads to more volatility in the exchange market.

capital controls in Malaysia (1998) did succeed in providing greater exchange rate stability, while controls in Thailand (1997) did not. On the contrary, Tamirisa (2004) finds no statistically significant effects of capital controls on real exchange rates in Malaysia (1998). However, Tamirisa performs her analysis on real exchange rates while Edison and Reinhart (2001a) analyze nominal exchange rates,[37] which aligns closer to our analysis of nominal ISK. Again, the timing of the implementation of the controls could play a big role in how effective they prove to be.

8.3 Model 3 - Monetary policy independence

In the following section, we will address the third hypothesis, namely if the capital controls were successful in increasing monetary policy independence. Based on the results from the augmented GARCH model on nominal exchange rates, we find little evidence that capital controls increased monetary independence when measured as the sensitivity of the exchange rate to domestic interest rate changes; the coefficient on the interaction term of capital controls and domestic interest rate changes is not statistically significant in the mean equation (see *table 7*). The fact that both the domestic interest rates and the interaction term of interest rates multiplied by the capital control dummy are insignificant suggest that domestic interest rate changes have not affected the exchange rate, neither before nor after the capital controls were implemented. However, the coefficient on global sensitivity is negative and significant in the mean equation, indicating that the capital controls have been able to reduce the transmission of global financial shocks to Iceland.

Although capital controls were able to reduce the transmission of global shocks to the Icelandic economy, the empirical results indicate that controls were not able to increase monetary policy independence. However, since the monetary policy does not seem to have affected the exchange rate before the capital controls were put in place, the results do not necessarily indicate that the Icelandic authorities failed to push for increased monetary independence, but rather that the monetary policy continued to have an insignificant impact on the exchange rate in capital control period.

Our results regarding monetary autonomy align with previous findings of the effectiveness of capital controls in Thailand (1997), which were also implemented prior to the peak of the financial crisis. Edison and Reinhart (2001a) found little evidence that capital controls increased monetary autonym in Thailand, while monetary independence appears to have increased in Malaysia (1998) during the capital control period.

[37] See *section 2* on Literature Review for a more detailed discussion.

Table 7: Augmented GARCH model: January 1st, 2006 – December 31st, 2010

Dependent Variable:	On-shore EURISK	
	Mean Equation	Variance Equation
$\Delta(\ln s_{t-1})$	0.0942***	-
	(-0.0325)	-
INT	0.0000	-0.0030**
	(0.0000)	(-0.0013)
VIX	0.0002***	0.0360***
	(-0.0001)	(-0.0023)
CDS	0.0000	0.0010***
	(0.0000)	(-0.0002)
$\Delta Comm$	0.013	69.5426***
	(-0.0137)	(-7.1507)
DCC	0.0024*	-4.7268***
	(-0.0014)	(-0.2066)
Δi	0.0005	-3.7491***
	(-0.0011)	(-0.5609)
Δr	-0.0051	2.2899***
	(-0.0033)	(-0.4618)
$DCC * \Delta i$	-0.0018	4.3979***
	(-0.0012)	(-0.8400)
$DCC * VIX$	-0.0002***	0.0545***
	(-0.0001)	(-0.0084)
No. of observations	1246	1246

Source: Authors' estimates
*Note: Robust standard errors are reported in parenthesis. Asterisks, ***, **, and *, denote statistically significance of coefficients at the 1%, 5%, and 10% levels, respectively.*

8.4 Model 4 - Exchange rate wedge

In order to analyze the fourth research hypothesis, namely if tightening of capital controls regulations made controls more effective by inducing a premium in the off-shore market, we turn our focus to the results from the exchange rate wedge regression. A point worth emphasizing is that the amendments to the capital controls were typically introduced after markets had closed and became effective the following day; thus, they were not expected by the market.

As can be seen in *table 8*, the coefficient on the dummy for when capital controls were originally implemented on October 10th, 2008, is positive and statistically significant. This confirms what we already knew, namely that capital controls contributed to creating the wedge between on- and off-shore exchange rates. Furthermore, the VIX index, the CDS spread of the Icelandic government, and the domestic-foreign interest rate spread are also statistically significant and have effects in the

direction that could be expected. Both global and domestic risk sentiment increase the wedge, which is reasonable given that increased economic turbulence is likely to make investors more prone to evading controls by trading in the off-shore exchange rate market. Further, an increase in the interest rate differential decreases the wedge as higher domestic interest rates compared to international rates provide less of an incentive to circumvent the capital controls. While the index of commodity prices and Central Bank interventions are statistically significant, their impact on the exchange rate wedge is minor.

***Table 8*: OLS model with exchange rate wedge: January 1st, 2006 – December 31st, 2010**

Dependent Variable:	**Wedge**
$(i - r)$	-4 .6672***
	(0 .5658)
VIX	0 .6626***
	(0 .1788)
CDS	0 .0879***
	(0 .0150)
INT	0 .0014*
	(0 .0008)
$Comm$	0 .0138***
	(0 .0039)
DCC (October 10th . 2008)	13 .7006**
	(5 .6974)
$DCC1$ (November 28th . 2008)	4 .1935
	(9 .6232)
$DCC2$ (March 31st . 2009)	-19 .3225***
	(6 .0997)
$DCC3$ (July 10th . 2009)	0 .6117
	(5 .7252)
$DCC4$ (October 31st . 2009)	54 .2937***
	(2 .8004)
$DCC5$ (April 30th . 2010)	27 .3112***
	(3 .7211)
$DCC6$ (June 14th . 2010)	-40 .1581***
	(2 .3505)
R-squared adjusted	0 .8384
No. of observations	1246

Source: Authors' estimates

*Note: Robust standard errors are reported in parenthesis. Asterisks, ***, **, and *, denote statistically significance of coefficients at the 1%, 5%, and 10% levels, respectively. The dates of the dummies are the dates at which the amendments were put in place. Furthermore, the dummies continue to take on the value of one for the remainder of the period analyzed.*

While the initial implementation of capital controls did have an impact on the wedge, passing the capital controls into law appears not to have affected the wedge as the coefficient on the November 28th, 2008, dummy is statistically insignificant. The results could perhaps be due to the fact that controls were already in effect at that point in time, and the legalization was more of an official formality that did not increase the effectiveness of the capital controls per se. However, what is noteworthy is that the November 2008 revision also included the repatriation requirement of foreign currency acquired by resident abroad in order to prevent circumvention via transactions between residents and nonresidents abroad. Although the repatriation of foreign exchange ought to make the controls more comprehensive and close some loopholes in the legislation, it appears to not have significantly impacted the wedge and thus, the effectiveness of the controls.

The October 2009 and April 2010 revisions appear to have made it more costly to evade the controls by inducing a premium in the off-shore market; the coefficients on the dummies are positive and statistically significant. The amendments made the controls more comprehensive by clarifying the law and closing loopholes that had been exploited to circumvent the controls. The revision in October 2009 seems to have been of particular importance as it included an amendment to address leakages through the offshore market, which had been the foremost channel for circumvention until then and had greatly undermined the foreign currency repatriation requirement (CBI, 2011). The importance of this change is in line with the conclusion by Ariyoshi et al. (2000) that the ability to control activity in the off-shore market may be influential in enhancing the effectiveness of capital controls by restraining outflows and curtailing speculative pressures.

In contrast to the October 2009 and April 2010 amendments, the March 2009 revision was also aimed at limiting evasions of the controls but it actually decreased the exchange rate wedge; the dummy is negative and statistically significant. Exporters had been circumventing the controls by issuing invoiced in ISK, but the March 2009 amendment closed that loophole by requiring invoices to be based on foreign currency rather than ISK. Although the amendment did make controls more comprehensive and made circumvention more difficult, it was not directly targeted at off-shore activities, which is probably the reason why it did not increase the wedge.

The July 2009 and June 2010 amendments were, to a large extent, aimed at expanding the authorities' legal right to enforce the controls. In the July 2009 revision, the investigative authority of the FSA was expanded and allowed for penalty provisions for unauthorized intermediation of foreign exchange transactions. Along the same lines, the June 2010 amendment to the capital controls assigned the CBI the sole jurisdiction over investigation of capital control evasions and increased their investigative authority. If these amendments would have resulted in more effective capital controls through stronger enforcement, the risk premium for evading the controls in the off-shore

market would have been expected to increase because of an increased likelihood of being caught. However, the empirical results stand in contrast to what was expected; the coefficient on the July 2009 dummy is insignificant, and the coefficient on the June 2010 dummy is negative and statistically significant. Judging from the results, it appears as if the amendments did not lead to an increased enforcement of the capital controls, at least not in the short-term. Perhaps the amendments did give room for stronger enforcement of capital controls in the long-run, which would not be reflected in a short-term change in the exchange rate wedge.

In sum, our analysis indicates that the amendments to the capital controls that *directly* addressed leakages to the off-shore market were successful in increasing the effectiveness of the controls. However, stronger enforcement appears to not have increased the effectiveness of capital controls, at least not as it is reflected in the exchange rate wedge in the short-term.

9. Conclusion

In this thesis, we sought to assess whether Icelandic capital controls have reached the policy objectives that motivated their imposition. Specifically, we analyzed *if capital controls on outflow did curtail capital outflows, reduce exchange rate fluctuations, support the ISK, and increase monetary policy independence.* In addition, we addressed the question whether the amendments made to the capital control regulations had enhanced effectiveness of the Icelandic capital controls on outflow.

Along the lines of previous literature, our results are mixed. On the one hand, we found clear evidence that Icelandic capital controls reduced exchange rate volatility and prevented further depreciation of the domestic currency. On the other hand, our analysis indicates that capital controls did not enhance monetary policy autonomy. Furthermore, the empirical results regarding the effectiveness of capital controls in reducing outflow were two-fold. The part of the analysis that relied on a panel fixed effect model was inconclusive while the descriptive statistics indicated that the controls had been able to prevent excessive capital outflows. Considering the fact that the validity of the panel fixed effect model can be questioned, the analysis based on descriptive statistics ought to be more reliable.

The existing literature and historical evidence point to the conclusion that controls on outflow have been largely ineffective in curtailing capital outflow. Although parts of our results indicate that controls were able to prevent large volumes of capital outflow, the analysis is not conclusive. In general, the main reasons for why capital controls fail to achieve their objectives are because the controls are not comprehensive enough and/or not sufficiently enforced, which makes them easy for investors to circumvent. The most prominent way controls in Iceland have been circumvented is through the unofficial off-shore exchange rate market for ISK. According to our assessment, the amendments to the capital controls that directly addressed leakages to the off-shore market were successful in enhancing the effectiveness of the controls by increasing the risk premium for trading in the off-shore market. However, stronger enforcement appears to not have increased the effectiveness of Icelandic capital controls, at least not as it is reflected in short term changes of the exchange rate wedge. Since the capital controls on Iceland were applied broadly to most channels of capital outflow and the restrictions have been successfully revised over time, the question remains if enforcement of the controls could and should be improved.

As emphasized in the previous literature, the timing of capital controls on outflow seems to have a large impact on the measurement of their effectiveness in research. The success of controls in Malaysia (1998) has largely been attributed to the fact that they were implemented late in the Asian crisis when the economy was already in the recovery phase. Regarding Icelandic controls, the capital restrictions were put in place before to the peak of the crisis, which is similar to the timing of capital

controls in Thailand (1997). Without taking any country specific circumstances into account, Icelandic capital controls appear to have been more successful than controls in Thailand (1997); they made the exchange rate deprecate less and stabilized the currency while controls in Thailand did neither. How much of the difference in effectiveness of the capital controls is due to Iceland being a developed country with high quality institutions and thus a higher ability to enforce the controls is yet to be explored and could be a topic for future research.

Although the Icelandic capital controls appear to not have effectively fulfilled all of their policy objectives, it should be noted that the capital controls may indeed have been a necessary measure following the severe meltdown in the financial sector in the fall of 2008. After all, capital controls did in fact provide support for the ISK, which one could argue was the most crucial objective of the controls given the large exposure of balance sheets of Icelandic companies and households to inflation and exchange rate changes. However, evidence suggests that the effectiveness of capital controls decreases over time, and capital controls in Iceland have already been in place longer than originally planned. According to the current liberalization strategy, the controls will, in a worst case scenario, remain in place until the end of 2015.

While this paper was focused on analyzing the effectiveness of capital controls in the specific case of Iceland, the effectiveness only tells half the story. Another topic of interest for policy makers should be the efficiency of capital controls, i.e. do the benefits of the restrictions ultimately outweigh the related costs? Although such an analysis is beyond the scope of this thesis, the efficiency of capital controls in Iceland would be an interesting topic for future research.

10. References

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11. Appendices

Appendix A: Chronology of key events in Iceland

Table 9: Financial Crisis in Iceland: Chronology of Key Events

Date	Key Event
29-Sep-2008	The Icelandic government takes over a 75% stake in Glitnir, one of the 3 largest banks in Iceland.
6-Oct-2008	Parliament passes the Act on Authority for Treasury Disbursements due to Unusual Financial Market Circumstances, no. 125/2008.[38]
6-Oct-2008	The value of the ISK falls by more than 20% in one day.
7-Oct-2008	The FSA intervenes in the operations of Landsbanki Íslands and appoints a resolution committee.
7-Oct-2008	The FSA intervenes in the operations of Glitnir and appoints a resolution committee.
9-Oct-2008	The FSA intervenes in the operations of Kaupthing Bank and appoints a resolution committee.
10-Oct-2008	The CB issues guidelines for financial institutions concerning limitations on the sale of foreign currency; temporary restrictions on foreign currency trading and movement of capital between Iceland and other countries are put in place
14-Oct-2008	The CB of Iceland draws a total of 400 m EUR on the currency swap agreements with the central banks of Denmark and Norway.
15-Oct-2008	The CB policy interest rates are lowered by 3.5 percentage points, to 12%.
15-Oct-2008	The CB sets up a daily auction market that should function as temporary foreign exchange arrangements.
28-Oct-2008	Capital controls are formally introduced in law; temporary restrictions on foreign currency trading and movement of capital between Iceland and other countries are put in place.
19-Nov-2008	IMF approves a 2-year Stand-By Arrangement for Iceland and a loan amounting to USD 2.1 bn.
19-Nov-2008	In addition, Iceland secures loans totaling some USD 3 billion from Denmark, Finland, Norway, Sweden, Russia, and Poland.
28-Nov-2008	Capital controls are formally introduced into the law, the main change from the previously issued guidelines was the additional requirement of repatriation of foreign currency acquired by residents.
4-Dec-2008	The interbank currency market resumes operation and the new Central Bank Rules on the Foreign Exchange Market come into effect.
12-Dec-2008	The parliament passes a law on the investigation of the background and causes of the collapse of Iceland's banks in 2008.
26-Jan-2009	The coalition government between the Independence Party and the Social Democratic Alliance is dissolved.
1-Feb-2009	A coalition between the Social Democratic Alliance and the Leftist Green Party temporary assumes control until elections take place in April.
31-Mar-2009	Amendments to the Foreign Exchange Act; exports of goods and services shall take place in foreign currency.
25-Apr-2009	Parliamentary elections and the temporary coalition between the Social Democratic Alliance and the Leftist Green Party remains in power.

[38] The act authorizes the FSA to adopt special measures, such as intervening in the operations of a financial institution, in a case of particular financial and/or operational difficulties experienced by a financial undertaking.

10-Jul-2009	Amendments to the Foreign Exchange Act, which expanded FSA's investigative authority and included penalty provisions for unauthorized intermediation of FX transactions.
16-Jul-2009	The Prime Minister, on behalf of the Government, sends the European Union an application for membership for Iceland.
5-Aug-2009	The CB announces its strategy for the phased removal of the capital controls.
31-Oct-2009	Amendments to the Foreign Exchange Act; it is stated unequivocally that the unilateral importation of offshore ISK is prohibited. At the same time, the first stage of capital account liberalization was taken, lifting restrictions of outflow of foreign direct investment made after 1 Nov 2009.
5-Jan-2010	The president of Iceland refuses to sign and confirm an Icesave law regarding payment of deposit insurances previously passed by the parliament and refers the matter to a national referendum.
24-Feb-2010	The European Commission concludes that Iceland meets all of the conditions required of an EU applicant, and it is recommended that membership negotiations with Iceland begin.
6-Mar-2010	The Icesave law is rejected with 98% of valid votes in a national referendum.
12-Apr-2010	Special Investigation Commission (SIC) publishes its report on the background and causes of the collapse of the Icelandic banks in 2008
14-Apr-2010	The volcanic glacier Eyjafjallajokull erupts, causing severe disturbances in air traffic in Iceland and across Europe.
30-Apr-2010	Amendments to the Foreign Exchange Act; the rules on foreign exchange are clarified, the maximum amount of foreign currency that can be purchased for travel is reduced, and specified exemptions are changed in order to remove all doubt about the legality of off-shore transactions.
14-Jun-2010	Amendments to the Foreign Exchange Act and the Customs Act assigning the CBI sole jurisdiction over investigations and fines in connection with surveillance of the Act and Rules on Foreign Exchange. In addition, investigative authority of the CBI was expanded even further.
31-Aug-2010	The Central Bank begins purchasing foreign currency from market makers in the interbank foreign exchange market.[39]
29-Sep-2010	The IMF approves the third (out of seven in total) review of Iceland's economic program.
10-Jan-2011	The IMF approves the fourth (out of seven in total) review of Iceland's economic program.
20-Feb-2011	The president of Iceland refuses to sign and confirm an Icesave law regarding payment of deposit insurances previously passed by the parliament and refers the matter to a national referendum.
25-Mar-2011	The CBI publishes a revised capital account liberalization strategy.
9-Apr-2011	The Icesave law is rejected with 60% of valid votes in a national referendum.

Source: The Central Bank of Iceland (2008-2011) and IMF (2008).

[39] The aim of the purchase was to expand the Bank's non-borrowed reserves. The Central Bank decided to buy 500 thousand EUR from each market maker on Tuesday of each week.

Appendix B: The Balance of Payments

IMF defines the balance of payments as the sum of the current account, the capital account, and the financial account. The capital and financial account captures capital flows between residents and non-residents. Capital inflow can be the result of foreign borrowing or decreases in foreign assets, and outflow is caused by debt repayments and increase in foreign assets. Negative values of the capital and financial account reflect a net capital outflow. The financial account records all flows of assets and liabilities and impacts the international investment position directly. The capital account includes transfers, such as debt forgiveness, transfer of capital assets by migrants, etc (IMF, 2009).

The fixed effect model is also applied to two sub-categories of the financial account that are of interest, namely foreign direct investment (FDI) and portfolio investment. FDI is a part of the financial account and includes transactions in which the investor acquires 10 percent or more of the ordinary share (equity capital) of a company or property. The FDI is, thus, intended to reflect investments where the owner obtains significant influence in the management of the asset. Direct investment can be divided into net outward investment by residents (assets) and inward investment by non-residents (liabilities) (IMF, 2009).

Portfolio investment captures net purchase of foreign securities (assets) by residents and net investment of non-residents in domestic securities (liabilities). The definition of foreign securities is based on the residence of the issuer of the security. Portfolio investment includes holdings in mutual funds, equities, and shareholdings of less than 10% in companies. Furthermore, portfolio investment includes holdings in debt instruments, such as bonds and notes, and money-market instruments, such as commercial papers (IMF, 2009).

Appendix C: The GARCH model explained

Ordinary least square regressions (OLS) assume that the variance of the unobservable error term conditional on the explanatory variables is constant; this assumption is called homoskedasticity or constant variance.[40] When the variance of the error term is, on the other hand, dependent on the explanatory variables, the error term exhibits heteroskedasticity or non-constant variance.[41] Although heteroskedasticity does not bias the OLS estimators, it does cause inconsistency in the confidence intervals and t-statistics since OLS standard errors depend on the estimators of variances, which are biased (Wooldridge, 2009). Instead of correcting the presence of heteroskedasticity in the OLS regression, GARCH (Generalized Autoregressive Conditional Heteroskedasticity) explicitly models the non-constant variance (Engle, 2001).

Heteroskedasticity is most often considered to be present in cross-sectional data sets. However, heteroskedasticity has also been known to be present in times series, especially in financial time series on asset returns. The risk level of an asset return is represented by the variance of that return. Since the risk level is typically not scattered randomly across time, some periods tend to be riskier than others, the risk of financial returns exhibit a certain degree of autocorrelation. Thus, financial time series tend to exhibit volatility clustering, i.e. varying amplitude of returns over time, including exchange rates (Engle, 2001). One stylized fact documented by empirical research on daily exchange rate is that they exhibit conditional heteroskedasticity (i.e. volatility clustering) with long term persistence in the conditional variance (Kiliç, 2007). Therefore, GARCH has become the standard empirical method in research by which the process underlying exchange rate volatility is modeled. Formally, the GARCH (p,q) model has the following general specifications:

$$Y_t = \mu + X'_t\theta + \varepsilon_t \tag{9}$$

$$\varepsilon_t|\Omega_{t-1} \sim N(0, \sigma_t^2) \tag{10}$$

$$\sigma_t^2 = \alpha_0 + \sum_{I=1}^{p} \alpha_i \varepsilon_{t-I}^2 + \sum_{j=1}^{q} \beta_i \, \sigma_{t-j}^2 \tag{11}$$

Where X is a vector of control variables, p and q are the order of the process, and the remaining variables are defined as previously. The GARCH model is an extension of the ARCH (Autoregressive Conditional Heteroskedasticity) model. While ARCH assumes the conditional variance is a function of past squared residuals, GARCH assumes that the variance depends on both past squared residuals *and* past variances. Thus, p specifies the number of lags in the ARCH term, $\sum_{I=1}^{p} \alpha_i \varepsilon_{t-I}^2$, and q specifies the number of lags in the GARCH term, $\sum_{j=1}^{q} \beta_i \, \sigma_{t-j}^2$ (Johnston and Scott, 2000).

[40] Homoskedasticity: $Var(\varepsilon \mid x_1, \ldots, x_k) = \sigma^2$ (Wooldridge, 2009).
[41] Heteroskedasticity: $Var(\varepsilon \mid x_1, \ldots, x_k)$ is a function of $x_1, \ldots, x_k$ (Wooldridge, 2009).

Appendix D: Overview of statistical tests

Statistical tests on the GARCH model with daily nominal exchange rates

A. **Engle's Lagrange Multiplier (LM) test for ARCH effects**

We use the Engle's Lagrange Multiplier (LM) to test for ARCH effects in the residuals. The p-value of the test is zero;[42] thus, we concluded that there are ARCH effects present and a GARCH model with robust standard errors is applied.

H0: no ARCH effects H1: ARCH (p) disturbance

A. **Portmanteau (Q) test for white noise**

We use the Portmanteau Q test for white noise to check for autocorrelation. We ran the test with 40 lags and since the resulting p-value was zero,[43] we concluded that the residuals are correlated. The GARCH model controls for autocorrelation.

H0: none of the autocorrelation coefficients up to lag s are different from zero

B. **BIC and AIC to test the optimal lag structure of the GARCH model**

We use the Akaike information criterion (AIC) and Schwarz's Baysian information criterion (BIC) to compare GARCH models with different lag structures. The rule of thumb is that the lower the AIC and BIC values the better. Experience has shown that the AIC often favors models with too many parameters and thus, BIC, which includes a penalty for additional parameters, is usually favored (Reider, 2009). Out of the models compared, both the AIC and BIC criterion support the GARCH(1,1) model (see *table 10*). Therefore, we use the default GARCH(1,1) lag structure in our analysis(Reider, 2009).

***Table 10*: Optimal lag structure for GARCH: AIC & BIC criterion**

	AIC	BIC
GARCH(1,1)	**-8628.088**	**-8540.917**
GARCH(1,2)	-8598.373	-8511.202
GARCH(2,1)	-8588.568	-8501.397
GARCH(2,2)	-8523.103	-8435.932

Source: Authors' calculations

Statistical tests on the panel fixed effect model

A. **Wald test for time fixed effects**

We perform a Wald test to test for the presence of time fixed effects in the panel fixed effect model. In the fixed effect model with capital account flows, the p-statistic is less than 0.05; thus, we reject

[42] Chi2 = 1005.593
[43] Portmanteau (Q) statistic = 1157.2901

the null hypothesis of no time fixed effect and include a quarter fixed effect dummy in the regression. Regarding the remaining four categories of capital flows, the p-statistics are significantly greater than 0.05; no time fixed effects are present.

H0: No time fixed effects H1: Time fixed effect present

B. **Modified Wald statistic for group-wise heteroskedasticity in fixed effect model**

We calculate a modified Wald statistic for group wise heteroskedasticity in the residuals of the panel fixed effect model for all five categories of net capital flows. The p-values for all types of capital flows equal zero; thus we reject the null hypothesis of homoskedasticity and use robust standard errors in the panel fixed effect model.

H0: Homoskedasticity H1: Group-wise heteroskedasticity

C. **Augmented Dickey-Fuller unit-root test for stationary**

We perform an augmented Dickey-Fuller unit-root test on the capital flow variables as a share of GDP and the current account as a share of GDP in order to test for stationary among the variables. The p-statistics are below 0.05; we can, thus, reject the null hypothesis of a unit root and conclude that the variables are generated by a stationary process. The results indicate that there is no need for adjustments in our model due to unit roots.

H0: Variable contains a unit root H1: Variable is generated by a stationary process

Statistical tests on the OLS model for the exchange rate wedge

A. **Breusch-Pagan / Cook-Weisberg test for heteroskedasticity**

We applied a Breusch-Pagan test for heteroskedasticity. The p-value equal zero; thus, we reject the null hypothesis of homoskedasticity and use robust standard errors.

Ho: Constant variance H1: Heteroskedasticity

Appendix E: Summary of variables

Table 11: Overview of variables and data sets used

Short-name in Model	Variable name	Further description	Highest availab. freq.	Used in GARCH model?	Used in FE model?	Source
onshore (s)	EURISK exchange rate on the official on-shore market		Daily	x		CBI
offshore	EURISK exchange rate on the off-shore market		Daily	x		CBI
INT	CBI interventions in the FX market	The CBI total turnover in the foreign exchange market (in m.ISK)	Daily	x		CBI
REIBOR (i)	Reykjavik Interbank Offered Rate	Overnight interest rates	Daily	x		CBI
US int (r)	The fed funds rate are the US interbank rates		Daily	x		US fed
i-r	interest rate difference		Daily	x		CBI & the US fed
VIX	Chicago Board Options Exchange Market Volatility Index	Implied volatility of the S&P 500 index. A proxy for global volatility	Daily	x		Reuters EcoWin
DCC	Dummy for capital controls	dcc=0 before 10 oct 2008 and dcc=1 from 10 oct 2008		x		
CDS	Credit default swap for the Icelandic government		Daily	x		Reuters EcoWin
Comm	Worldmarket price of aluminium	Iceland´s largest single export commodity is aluminium. Proxy for export prices	Daily	x		Reuters EcoWin
ca	Current account, net		Quarterly		x	CBI / IMF
cap_fin_ac	Capital and financial account , net		Quarterly		x	CBI / IMF
cap_ac	Capital transfer, net		Quarterly		x	CBI / IMF
fin_ac	Financial account, net		Quarterly		x	CBI / IMF
FDI	Direct investment, net		Quarterly		x	CBI / IMF
portf	Portfolio investment, net		Quarterly		x	CBI / IMF
Other	Other investment, net		Quarterly			CBI