An Empirical Investigation of the International Fisher Effect

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TABLE OF CONTENTS

ABSTRACT I

SAMMANFATTNING II

LIST OF FIGURES V

Chapter 1 INTRODUCTION 5
  1.1 Purpose 6
  1.2 Method 6
  1.3 Scope 7
  1.4 Outline 8

Chapter 2 THEORETICAL FRAMEWORK 8
  2.1 Purchasing Power Parity 9
    2.1.1 Empirical evidence 10
  2.2 The Fisher Effect 11
    2.2.1 Empirical evidence 14
  2.3 The International Fisher Effect 14
    2.3.1 Empirical evidence 17

Chapter 3 THE REGRESSION MODEL 17
  3.1 The efficient market hypothesis 18
  3.2 The regression model 19
  3.3 The data 20

Chapter 4 THE REGRESSION RESULTS AND ANALYSIS 22
  4.1 The regression results for United States-Sweden 23
  4.2 The regression results for United States-Japan 25
  4.3 The regression results for United States-United Kingdom 26
  4.4 The regression results for United States-Canada 27
4.5 The regression results for United States-Germany

Chapter 5 CONCLUSIONS

REFERENCES
LIST OF FIGURES

Figure 2.1 Purchasing Power Parity 6

Figure 2.2 The Fisher Effect 9

Figure 2.3 The International Fisher Effect 12

Figure 4.1 Relationship of the change in the US-Swedish exchange rate to US-Swedish nominal interest differential 20

Figure 4.2 Relationship of the change in the US-Japanese exchange rate to US-Japanese nominal interest differential 22

Figure 4.3 Relationship of the change in the US-UK exchange rate to US-UK nominal interest differential 23

Figure 4.4 Relationship of the change in the US-Canadian exchange rate to US-Canadian nominal interest differential 24

Figure 4.5 Relationship of the change in the US-German exchange rate to US-German nominal interest differential 25
Chapter 1
INTRODUCTION

The postwar period has been characterized by a significant liberalization in international trade and investment and financial markets throughout the world has become more integrated. The major economies have removed their controls on the movement of capital. The technical innovation has at the same time made it possible to transfer capital throughout the world at the speed of light. As a result the capital has become more mobile. A more mobile capital will undoubtedly affect the value of different currencies and interest rates (Hässel & Norman 1994, 14).

Free international capital movements also contributed to the break down of the Bretton Woods system in the 1970s. When the financial markets became more internationalized it led to an increase in the amount of capital trying to take advantage of currency swings. The Bretton Woods system with fixed and pegged exchange rates proved to be insufficient to cope with currency speculation. The international capital flows had made it an unstable monetary system. In 1976 were a new international system agreed on in Jamaica. Currencies were this time allowed to float and the references to the price of gold were abandoned (Solnik 2000, 5-6).

The current international monetary system can be described as a hybrid system, where the basic market mechanisms for establishing exchange rates include the free float, managed float, target-zone arrangement and fixed-rate system. This system has led to rapidly fluctuating exchange rates, creating both problems and opportunities for actors dealing with foreign currencies (Shapiro 1998, 55-56). To protect oneself against these rapid currency changes new instruments were developed on the world capital markets in the 1970s and 1980s, such as options, swaps, futures and warrants (Internet 1).

During the last two decades a growing number of countries has abandoned their fixed or pegged exchange rate arrangements in favor of more flexible arrangements. In 1984, 21.6% of all countries had managed or independently floating arrangements. 10 years later in 1994 this number had risen to 50.6% (International Monetary Fund 1985, 18; 1995, 18). The trend
toward greater exchange rate flexibility is a consequence of rising international capital mobility. The rise of the international capital mobility has made it difficult for many governments to defend their fixed or pegged exchange rates or even pursue independent macroeconomic policies (Eichengreen 1996, 188). Defending an exchange rate could turn out to be very costly and even pointless when speculators attack a currency. Governments trying to defend their currencies have been forced to maintain high interest rates to prevent capital outflows. High interest rates that actually hinder the economic growth and further hurting the economy (Solnik 2000, 74).

Theories aiming to explain and understand the interaction of international monetary variables will become increasingly more important if the deregulation and international integration of financial markets throughout the world continues. One theory linking exchange, interest and inflation rates is the International Fisher Effect. It states that the future spot rate of exchange can be determined from the nominal interest differential. The real interest rates will in turn be equalized across the world through arbitrage. This means that the difference in the observed nominal rates will be stemming from differences in expected inflation rates. The differences in anticipated inflation that are imbedded in the nominal interest rates are expected to affect the future spot rate of exchange. The effect on the exchange rate is also more likely to occur under flexible exchange rate arrangements, where the currencies exchange rates are allowed to fluctuate without the intervention of governments.

1.1 Purpose
The purpose of this thesis is to describe the theory of the International Fisher Effect and test its empirical validity in the long run.

Question
• According to the International Fisher Effect it will be a tendency for countries with relatively high nominal interest rates to have depreciating currencies and those with relatively low nominal interest rates to have appreciating currencies. In other words, the nominal interest differentials might be used to anticipate currency changes. Therefore I ask if there is a tendency for nominal interest differentials to offset exchange rate changes?

1.2 Method
When describing the theory of the International Fisher Effect a descriptive method will be used. For this purpose appropriate literature will be employed. The chosen literature for the
The descriptive section consists mainly of various financial literatures. The sources in use complement each other and I have tried to form a general picture of the theory of the International Fisher Effect.

For the empirical investigation a statistical test will be employed to historical exchange rates and nominal interests. Quarterly nominal interest differentials relative to US interest rates for five countries between the years 1993-2000 will be calculated together with exchange rate changes for the same five countries relative to the US dollar. A regression analysis will then be applied to the nominal interest differentials and the exchange rate changes. The regressions will use Ordinary Least Squares (OLS) estimates. The regression tests whether nominal interest differentials are a good forecast for changes in the future spot rates of exchange for the tested time frame and respective country pair.

Since I am comparing all countries to the US dollar there is a risk that the result will be country specific. The fact that I am comparing all changes relatively to the US might be part of why the International Fisher Effect holds, or not holds. This problem can of course be avoided by for example choosing more than one home country. But again, the result might only be valid for the chosen country pairs. If one should compare changes in exchange rates to nominal interest differentials to only one country I believe USA to be the most appropriate one. The US dollar is the most widely traded and used currency in the world today. The US dollar is used in 50% of all global commercial transactions and 80% of all global financial transactions (Internet 2).

Another methodological problem is that I might get a time specific result. The result might only be valid or not valid during the chosen time frame. This might be avoided by choosing more than one time period. However, the result from such study will just state that the International Fisher Effect holds or not holds for those time frames. One can argue that the result would still be time specific.

1.3 Scope
The empirical investigation covers quarterly data for the nominal interest rates and exchange rates between 1993 and 2000. For the study I have selected countries with floating exchange rates since the effects on the exchange rate is more likely to occur when the currency is allowed to fluctuate without government intervention. The chosen countries that will be
compared to the United States are Sweden, Japan, United Kingdom, Canada and Germany. These countries currencies are during the investigated period involved in the majority of all foreign exchange transactions (Solnik 2000, 17).

1.4 Outline
Chapter 2 begins with a description of the theoretical framework. It describes the Purchasing Power Parity, the Fisher Effect and the International Fisher Effect and how these three parity relations relate to each other. The chapter also covers some results from earlier studies.

The regression model is presented in chapter 3. The chapter starts with a discussion of the efficient market hypothesis followed by a description of the regression model and the data. Chapter 4 presents the empirical results from the regressions and gives an interpretation and analyze of the regression results. Finally, chapter 5 summarizes the thesis by producing some conclusions.

Chapter 2
THEORETICAL FRAMEWORK
The purpose of this chapter is to describe the theory of the International Fisher Effect and illustrate how it relates to the domestic Fisher Effect and the Purchasing Power Parity. The chapter starts with a description of the theory of Purchasing Power Parity, followed by an explanation of the Fisher Effect. Finally, these two theories will be connected to the theory of the International Fisher Effect. The chapter also present some empirical evidences for the Purchasing Power Parity, the Fisher Effect and the International Fisher Effect, where conclusions from some other studies will be presented. They demonstrate, as you will see, a somewhat diversified picture.

2.1 Purchasing Power Parity

Purchasing Power Parity (PPP) can be divided into two versions: absolute PPP and relative PPP. The absolute version states that the real price of a good must be the same in all countries. That is, all goods obey the law of one price. The relative PPP is the most commonly used version of PPP and also the one I am referring to when talking about Purchasing Power Parity. The relative version of PPP states that the exchange rate between any two countries will adjust to reflect changes in the price levels of the same two countries (Solnik 2000, 36-37). For example, if inflation is 5% in Sweden and 1% in the United States, the krona value of the US dollar must fall by about 4% to equalize the krona price of goods in the two countries. The purchasing parity relation can be written as follows:

\[
\frac{(S_{t+1} - S_t)}{S_t} = \frac{(i_{h,t} - i_{f,t})}{(1 + i_{f,t})}
\]

(1.\$)

Where:

- \(S_t\) is the domestic currency value of one unit of foreign currency at time \(t\);
- \(S_{t+1}\) is the spot exchange rate at time \(t+1\);
- \(i_{h,t}\) is the inflation rate at time \(t\) in the home country and;
- \(i_{f,t}\) is the inflation rate at time \(t\) in the foreign country.

The Purchasing Power Parity can also be presented in following approximation:

\[
\frac{(S_{t+1} - S_t)}{S_t} \equiv i_h - i_f
\]

(2.2)
This approximation relates inflation to exchange rate changes stating that inflation differentials will be offset by exchange rate changes. Equation 2.2 is valid if the foreign inflation rate is relatively small (Demirag & Goddard 1994, 72; Shapiro 1998, 159). Equation 2.2 is also illustrated in figure 2.1 below.

![Graph showing purchasing power parity](image)

**Figure 2.1 Purchasing Power Parity**

(Source: Shapiro 1998, p.159)

The vertical axis measures the percentage currency change and the horizontal axis shows the inflation differential. The parity line shows all points for which \((S_{t+1} - S_t)/S_t = i_h - i_f\) and consequently shows all equilibrium points.

All other things being equal, an increase in a country’s expected rate of inflation or actual inflation\(^1\) makes that country’s currency more expensive to hold over time. In other words, PPP says that countries with high rates of inflation should have depreciating currencies relative to countries with lower rates of inflation (Shapiro 1998, 159).

2.1.1 Empirical evidence

There is evidence that the famous Big Mac index\(^2\) of currencies put forward by *The Economist* each year holds up well in the long run but not in the short run (Daniels & Radebaugh 1998, 1998).

---

\(^1\) The distinction between expected and actual inflation does not matter if expectations are rational.
424). Also Webster (1987) rejected PPP in the short run. Galliot (1971) presents evidence stating the validity of the PPP in the long run. He examined the relationship between the inflation rates in the USA relatively to some of its trading partners and the relatively changes in the exchange rates between the same nations. Galliot came to the conclusion that price changes are the major determinants of the exchange rate in the long run. Shapiro (1998) presents another evidence of a long run PPP, where he compares the relative inflation rates for 22 countries with the relative change in the exchange rate. He finds that those countries with the highest inflation rates also had the largest depreciation of their currencies. Other studies come to the conclusion that the PPP holds up well for some time periods but does not hold for others (Krugman & Obstfeld 1997, 411).

To sum up: Purchasing Power Parity seems to be a poor explanation for short-term exchange rate movements, but many studies provide supportive evidence in favor of long-run PPP. Though the long run evidence for a PPP seems only to be valid for certain time intervals. Although there is no clear-cut conclusion to be drawn, the relative purchasing power is used by international finance experts as a key determinant of long run movements in exchange rates (Demirag & Goddard 1994, 74-75).

2.2 The Fisher Effect

The domestic Fisher Effect is the theory stating that the nominal interest rate $r$ in a country is determined by the real interest rate $R$ and of expected inflation rate over the term of the interest rate $E (i)$ as follows:

\[
(1 + r) = (1 + R)(1 + E (i))
\]  

(2.3)

As with the PPP there also exists a generalized version of this parity condition. The generalized version of the Fisher Effect states that real returns are equalized worldwide through arbitrage. If arbitrage is permitted, national capital markets will be integrated worldwide. This means that real interest rates are determined by the global supply and demand of funds. In an integrated capital market is the domestic real interest dependent upon events both inside and outside the country. If the real return is higher in one country than another it would lead to a flow of capital to the country with the higher rate of return until

---

2 The price of a Big Mac is used to estimate the exchange rate between the US dollar and other currencies (Internet 3).
expected real returns becomes equalized. The implicit assumption here is that investors view foreign and domestic assets as perfect substitutes (Shapiro 1998, 163-167).

However, many factors can prevent capital from freely flowing across borders to take advantage of real interest differentials. If real interest differentials do exist they might be due to one or more of the following factors:

- **Psychological barriers:** These barriers to the free flow of capital might incorporate an amount of uncertainty. Investors are generally more familiar with domestic markets than foreign markets. Different languages, time zones, sources of information, etc. might limit capital flow across borders (Solnik 2000, 161).

- **Legal constraints:** Legal restrictions facing investors might vary amongst different countries and hinder investors from taking advantage of real interest differentials (ibid).

- **Transaction costs:** Access to information might be costly and transactions often involve costs in the form of brokerage and management fees\(^3\) (ibid).

- **Taxes:** Taxation might function as a discriminatory factor if taxes are higher in one country than another and hence restrict the flow of capital across borders (Shapiro 1998, 167).

- **Political risk:** If political risk is assumed to exist on foreign investments it might dampen the amount of investments. Political risk can be in the form of fear of expropriation of capital investments from a foreign country\(^4\) (Solnik 2000, 161).

- **Currency risk:** The fear of devaluation and/or depreciation of a foreign currency might deter investments in that particular currency (Shapiro 1998, 167).

If capital markets are perfect and capital is completely mobile it will ultimately lead to an equalization of real interest rates across the world. From this follows that in equilibrium, the nominal interest rate differential would approximately equal the expected inflation rate

\(^3\) The deregulation of capital markets has however lowered the transaction costs (Solnik 2000, 151).

\(^4\) The political risk in the major markets is believed to be small (ibid, 161).
differential (Shapiro 1998, 164). This is shown in equation 2.5, where \( r_h \) and \( r_f \) is the home and the foreign nominal interest rates (Demirag & Goddard 1994, 75).

\[
\frac{(1 + r_{h,t})}{(1 + r_{f,t})} = \frac{(1 + E(i_{h,t}))}{(1 + E(i_{f,t}))}
\]  

Equation 2.4 can be approximated by equation 2.5 if \( r_h \) and \( E(i_f) \) are relatively small. By subtracting 1 from both sides of equation 2.4 and assuming \( r_h \) and \( E(i_f) \) are relatively small we get:

\[
r_h - r_f = E(i_h) - E(i_f)
\]  

Equation 2.5 is shown graphically in figure 2.2.

![Figure 2.2 The Fisher Effect](source: Shapiro 1998, p.165)

The horizontal axis shows the difference in the expected inflation rates between the home country and the foreign country. The vertical axis shows the nominal interest rate differential between the home country and the foreign country for the same time period. The parity line shows all points for which \( r_h - r_f = i_h - i_f \) and consequently constitutes all possible equilibrium positions. In effect, the generalised version of the Fisher Effect says that countries with high
rates of inflation should have higher nominal interest rates than countries with lower inflation rates (Shapiro 1998, 165).

2.2.1 Empirical evidence
Most studies on the Fisher Effect have not been able to establish any relationship between interest rates and expected inflation rates. However, there has been found to be a relationship between current interest rates and past inflation rates and this is often interpreted as evidence in favor of the Fisher Effect (Demirag & Goddard 1994, 75). Shapiro (1998) compares the inflation rates with nominal interest rates for 22 countries. He comes to the conclusion that countries with higher inflation rates generally have higher interest rates. This is according to the author consistent with the hypothesis that most of the variation in nominal interest rates across countries is due to differences in inflationary expectations. Fama (1975) finds in his study a relationship between nominal interest rates and inflation rates. His result thus supports the Fisher Effect. Booth & Ciner (2001) find a one-to-one relationship between 1-month Eurocurrency interest rates and inflation rates. They also present evidence that the 1-month Eurocurrency rate contains information about the future inflation. Mishkin (1992) finds no support for a short run Fisher Effect. Coppock and Poitras (1999) find evidence that the interest rate fail to fully adjust to inflation.

To sum up: There are many conflicting evidence for the Fisher Effect. No clear-cut conclusion can be drawn and the outcome of the studies might vary with the methodologies used. However, as with the studies on the empirical evidence for the PPP it seems like the Fisher Effect fails to hold more in the short run than in the long run. Many studies support the theory of the Fisher Effect in the long run.

2.3 The International Fisher Effect
The International Fisher Effect is the international counterpart of the Fisher Effect. It can be seen as a combination of the generalized version of the Fisher Effect and the relative version of the Purchasing Power Parity. The generalized version of the Fisher Effect states that the real interest rates across countries will be equal due to the possibility of arbitrage. If the real rate is equal between different countries, it follows that the differences in their observed nominal rates must arise from differences in expected inflation. The relative version of the Purchasing Power Parity implies that inflation differential will be offset by exchange rate changes. Recall equation 2.1 and equation 2.4:
By combining these two equations we get the International Fisher relation:

\[
\frac{(S_{t+1} - S_t)}{S_t} = \frac{(i_{h,t} - i_{f,t})}{(1 + i_{f,t})} \quad \text{and} \quad \frac{(1 + r_{h,t})}{(1 + r_{f,t})} = \frac{(1 + E(i_{h,t}))}{(1 + E(i_{f,t}))}
\]

The International Fisher Effect proposes that the changes in the spot rate of exchange between two currencies will be equal to the differences in their nominal interest rates (Demirag & Goddard 1994, 76). For example, a rise in the Swedish inflation rate relatively to the US will cause a depreciation of the Swedish krona relative to the US dollar (i.e. PPP). The nominal interest rate in Sweden will also rise relative to the US nominal interest rate (i.e. Fisher Effect).

The adjustment of exchange rate to nominal interest differentials between countries can come about either directly through flow of capital across international money markets, or through some sort of activity between the goods and money markets, some real cross-border investment activity or change in trade patterns in the goods market, that all in all still indirectly ensure nominal interest differentials are still, on average, offset by exchange rate changes (Internet 4).

Investors speculating on the future spot rate interested in making a profit would move capital from countries with low interest rates to countries with high interest rates. This movement of capital would ultimately cause a movement in the exchange rate, eliminating all profit opportunities. The movement in the exchange rate should on average offset the nominal interest differential. From this follows that the nominal interest rate differential is an unbiased predictor of future changes in the spot exchange rate. However, nominal interest differentials should not be seen as a particularly accurate predictor of future changes in spot rate of exchange, it just means that prediction errors tend to cancel out over time (Shapiro 1998, 172; Demirag & Goddard 1994, 76).

The purchase of a foreign asset is not just an investment in a security that pays a given rate of interest; it is also an investment in a foreign currency, where the return depends on the
appreciation or depreciation of the exchange rate. The International Fisher Effect says that the return on a foreign investment will be offset by an exchange rate change. Consequently, an investor that consistently purchases foreign assets will on average earn a similar return as if investing in purely domestic assets.

If the foreign nominal interest rate, \( r_f \) is relatively small can equation 2.6 be approximated by following equation:

\[
    r_h - r_f = \frac{(S_{t+1} - S_t)}{S_t}
\]  

(2.7)

We get this approximation of the International Fisher Effect by subtracting 1 from both sides of equation 2.6 (Shapiro 1998, 171). Equation 2.7 is sometimes called uncovered interest parity. “Uncovered” refers to the fact that the future spot rate, \( S_{t+1} \) is not known with certainty at time \( t \) (Dornbusch, Fisher & Startz 1998, 400). Equation 2.7 is shown graphically in figure 2.3 below.

![Figure 2.3 The International Fisher Effect](Source: Shapiro 1998, p. 172)

The vertical axis in figure 2.3 shows the expected change in home currency value of the foreign currency and the horizontal axis shows the nominal interest rate differential between the same two currencies for the same time period. If \( r_h > r_f \) we can expect an appreciation of
the foreign currency and if \( r_h < r_f \) we can expect a depreciation of the foreign currency. The parity line shows all points for which \( r_h - r_f = (S_{t+1} - S_t)/S_t \) and consequently shows all equilibrium points (Shapiro 1998, 171-172).

2.3.1 Empirical evidence

As with the relative PPP and the Fisher Effect it has been shown that there is conflicting evidence also for this parity relation. Aliber and Stickney (1975) calculated the percentage deviation from the Fisher Effect for thirteen countries, constituting both developed and developing countries for the period 1966-71. They used the average annual deviation as a measure for long-term validity and the maximum annual deviation as a measure for short-term validity. They concluded that the International Fisher Effect holds in the long run because the average annual deviation tended to be zero. The maximum annual deviation was however too large to support the theory in the short run. Another study indicating a long-run tendency for interest differentials to offset exchange rate changes were made by Giddy and Dufey (1975). Robinson and Warburton (1980) disputed the validity of the International Fisher Effect. They argued that there according to the Fisher Effect the possibility to earn a higher interest return would be eroded in the medium term by the appreciation of the currency with the lower interest rate relatively to the currency with the higher interest rate. In their study they created four filter rules for placing and switching money in three-month US treasury bills or three-month Eurocurrency deposits. They concluded that superior returns could be earned and therefore argued that the International Fisher Effect does not hold empirically. Kane and Rosenthal (1982) studied the Eurocurrency market for six major currencies during the period 1974 to 1979 and their study gave support to the theory of the International Fisher Effect.

To sum up: There are contradictory evidences for the existence of an International Fisher Effect. This might however not come as a surprise given that the evidence for the International Fisher Effect is considered to be less convincing than the evidences for the Purchasing Power Parity and the Fisher Effect (Demirag & Goddard 1994, 77).

Chapter 3

THE REGRESSION MODEL
The theoretical framework described in chapter two constitutes the necessary background material for the following chapter. The chapter starts with a discussion of the efficient market hypothesis, followed by a description of the regression model. The subsequent section discusses the collected data material and the revised data.

3.1 The efficient market hypothesis

Following section discusses the efficient market hypothesis. It carries some important assumptions about how the foreign exchange market might work and how quickly exchange rates and nominal interest rates reflect new information. In accordance with the International Fisher Effect should this new information represent the nominal interest differentials and the nominal interest differential would in turn be due to differences in expected inflation.

A market in which the actual price incorporates all currently available relevant information is called an efficient market. In an efficient market will any new relevant information immediately and fully be reflected in prices. Such a market would contain numerous of well-informed actors with easy access to new information and whose trading activities cause prices to rapidly adjust to new information. This assumes expectations to be rational. When prices adjust to new information the efficient market exclude any certain profits from speculation. This means that price changes cannot be predicted unless new information becomes accessible. This relates to capital market integration discussed earlier in section 2.2. An integrated world financial market would achieve international efficiency when capital flows across markets take advantage of any new information present throughout the world.

The foreign exchange market is sought to have the characteristics of an efficient market. This means that exchange rates will quickly adjust to any new information. All information should immediately be reflected in the exchange rates (Demirag & Goddard 1994, 82; Parkin & King 1995, 471-475). In the context of nominal interest rates it means that the nominal interest rates will contain unbiased estimates of expected inflation rates as predicted by the Fisher Effect (Rodriguez & Carter 1984, 122). This would mean that nominal interest differentials could be used to predict future exchange rate changes.
However, changes on the exchange rates can also take place through changes in trade patterns in the goods market, some sort of activity between the goods and money markets or changes in real cross-border investments. From this it can be concluded that the effects on the exchange rates are more likely to occur if free trade is present and the currencies exchange rates are allowed to fluctuate without the intervention of governments. This is why I have chosen to study floating currencies, which are currencies whose value is set primarily by market forces.

The next section describes the regression model with respect to the efficient market hypothesis. It integrates the theoretical model with the forthcoming statistical test.

### 3.2 The regression model

In an efficient market are all information immediately reflected in the exchange rates. Rational market participants should base their forecasts on all available information. The expected future spot rate at time $t+1$ given an information set, $\Phi_t$, at time $t$, can be denoted:

$$E(S_{t+1}, \Phi_t)$$

From this follows that the expected future spot rate at time $t+1$ based on all available information at time $t$ should on average be equal to the future spot rate:

$$S_{t+1} = E(S_{t+1}, \Phi_t)$$

We can also add an error term, $\mu_{t+1}$, to expression 3.2. The error term is defined as the difference between the realized future spot rate and the expected future spot rate. If market participants are rational should the error term be uncorrelated with the information available at time $t$. Any new information available at time $t$ should be reflected in the expectations and deviations from the expected value should only be caused by unpredictable news (Solnik 2000, 156). If expectations are rational and unbiased, then:

$$S_{t+1} = E(S_{t+1}, \Phi_t) + \mu_{t+1}$$
Linking this reasoning to the discussion of the International Fisher effect described in chapter 2.3, one should expect the exchange rate to change in relation to nominal interest differentials. If we add an error term to the International Fisher equation presented earlier in equation 2.6 we get:

\[
(S_{t+1} - S_t)/S_t = (r_{h,t} - r_{f,t})/(1 + r_{f,t}) + \mu_{t+1}
\]

That is, the percentage change in the expected spot rate of exchange should equal the percentage nominal interest differential. Thus, the regression model takes the following form:

\[
(S_{t+1} - S_t)/S_t = \alpha + \beta ((r_{h,t} - r_{f,t})/(1 + r_{f,t})) + \mu_{t+1}
\]

A t-test will be applied to \(\alpha\) and \(\beta\), whose hypothesized values are 0 and 1 respectively. The regressions use Ordinary Least Squares estimates of \(\alpha\) and \(\beta\). Interpreted literally, \(\alpha\) shows the value of the exchange rate change when the nominal interest differential is 0, that is when the nominal interest differential is 0 the exchange rate should not change and hence, also equal 0. When \(\beta\) equals 1 it means that a 1 percent increase in the nominal interest differential will lead to a 1 percent offsetting change in the exchange rate. That is, if the nominal interest rate is one percent higher in the United States than in the foreign country, the US dollar will depreciate by one percent relatively to the foreign currency.

### 3.3 The data

The data consists of quarterly nominal interest rates for six countries and quarterly exchange rates between the US dollar and five other currencies between the years 1993-2000, except for Germany, which contains data for the years 1993-1998. The data has been collected from *International Monetary Fund: International financial statistics* (various issues). The quarterly exchange rates are market rates, which are exchange rates largely determined by market forces.

The rates are daily averages of spot rates quoted for the US dollar on national markets expressed as national currency units per US dollar. However, *IMF: International Financial*
Statistics presents the British pound/US dollar exchange rate as US dollars per pound. To get the direct quote the reciprocal has been taken of the US dollar/British pound exchange rate by dividing the presented rates by 1 as follows:

\[
\frac{1}{\$/\£}
\]  

(3.6)

The quarterly nominal interest rates are averages of monthly figures and the monthly data are in turn averages of daily rates. The definition of the nominal interest rates for the six countries are as follows:

- United States: certificates of deposit.
- Sweden: 3-month Treasury discount notes.
- Japan: 3-month interbank rate.
- United Kingdom: 3-month interbank rate.
- Canada: certificate of deposits.
- Germany: 3-month interbank rate.

The chosen nominal interest rates are assumed to have identical risk characteristics. These nominal interest rates are also used by OECD as a definition of short-term interest rates and could therefore be trusted to be identical and hence, comparable (OECD 2001, 282).

The collected data material has then been revised by calculating the percentage nominal interest differential and the percentage exchange rate change for different quarters and different country pairs, where the United States is the home country. The nominal interest differential has been computed by taking the US nominal interest rate minus the foreign nominal interest rate divided by one plus the foreign nominal interest. The exchange rate change contains the exchange rate change from one quarter to another where the exchange rate is expressed as foreign currency units per US dollar. It has been computed by taking the exchange rate at time \(t+1\) minus the exchange rate at time \(t\), divided by the exchange rate at time \(t\). These calculations are continued until we get 31 observations for each country pair, with the exception of Germany where we get 23 observations.

These figures will then be compared. For instance, the nominal interest differential in the first quarter of 1993 between the United states and Japan is compared and contrasted to the

---

5 The German rates were after 1998 replaced by Euro zone rates.
exchange rate change of the Yen/US dollar between the first and second quarter of 1993. These nominal interest differentials should, according to the International Fisher Effect, on average be offset by exchange rate changes. This proposition will be tested in the next chapter.

Chapter 4
THE REGRESSION RESULTS AND ANALYSIS
This chapter aims to test the theory of the International Fisher Effect empirically. Employing regression analysis to quarterly nominal interest differentials and exchange rate changes will make this possible. The following sections present the outcome from the regressions including analysis. The results include 31 observations for each country pair, with the exception of United States-Germany, which includes 23 observations, and a total of five country pairs. The first part covers the regression result from United States-Sweden followed by United States-Japan, United States-United kingdom, United States-Canada and finally United States-Germany.

4.1 The regression results for United States-Sweden

The regression from US-Sweden gave the following outcome:

R-squared = 0.115178.
Constant $\alpha = 0.012061$.
Variable $\beta = 0.497179$.

The acceptance region at a 5% significance level for $\alpha$ is $-0.001453 < \alpha < 0.025575$.
The acceptance region at a 5% significance level for $\beta$ is $-0.026178 < \beta < 1.020537$.

The R-squared tell us how much of the variation in the dependent variable the explanatory variable can explain. The R-squared for US-Sweden turned out to be very low. Only 11.5% of the quarterly changes in the SKr/$ exchange rate can be explained by the nominal interest differentials. This leaves 88.5% of the quarterly changes in the exchange rate to be explained by other factors.

The null hypothesis that $\alpha = 0$, $\beta = 1$ will be rejected if the hypothetical values of $\alpha$ and $\beta$ lie outside their respective acceptance regions. However, both $\alpha$ and $\beta$ lie within their acceptance regions at 5% significance and $H_0$ cannot be rejected. This means that we can be 95% confident that the true values of $\alpha$ and $\beta$ lie somewhere inside their respective acceptance regions. The result also illustrates that a 1% increase in the nominal interest differential, on average, lead to approximately a 0.5% offsetting change in the SKr/$ exchange rate. The $\alpha$-value, in turn, says that if the nominal interests in the United States and Sweden are the same,
the change in the exchange rate would on average equal 0,012%. This is practically the same as a none-change. Figure 4.1 shows the graphical result of the regression from US-Sweden.

The vertical axis in figure 4.1 shows the percentage change in the exchange rate SKr/$ and the horizontal axis shows the nominal interest differential. Unsurprisingly, $s_{t+1}$ is frequently lower or higher than might have been expected at time $t$. This gives also an illustration to the low explanatory power of the R-squared. A value of $R^2 = 1$ would indicate that all observations lie exactly on the regression line.

By studying the regression diagram we find one outliner that negatively affects the result. During the second quarter of 1993 the Swedish krona depreciated against the US dollar by 8%, which is illustrated by the upper left dot. This might be due to the fact that Sweden abandoned their fixed exchange rate regime during the autumn 1992 after a turbulent period, and allowed the krona to float freely. It might be feasible to assume that the market forces did not regain their confidence in the Swedish krona until the third quarter of 1993 when the krona appreciated against the US dollar. If the three first quarters of 1993 would be excluded in the study, the result from the regression would be much more satisfying with $R^2 = 0,373453$, $\alpha = 0,0071$ and $\beta = 1,042582$, where both $\alpha$ and $\beta$ lie within their respective acceptance regions. This result would imply that the relation between nominal interest differentials and exchange rate changes is roughly as predicted by the theory. That is, the
nominal interest differentials are on average offset by exchange rate changes as implied of the value of $\beta = 1.042582$, which is closed to the hypothesized value of 1.

4.2 The regression results for United States-Japan

The regression from US-Japan generated following outcome:

R-squared = 0.08894.

Constant $\alpha = -0.03874$.

Variable $\beta = 0.927259$.

The acceptance region at a 5% significance level for $\alpha$ is $-0.08857 < \alpha < 0.011095$.

The acceptance region at a 5% significance level for $\beta$ is $-0.19986 < \beta < 2.054376$.

The R-squared for US-Japan turned out to be very low. Only 8.9% of the quarterly changes in the Yen/$ exchange rate can be explained by the nominal interest differentials. This leaves 91.1% of the quarterly changes in the exchange rate to be explained by other factors.

Both $\alpha$ and $\beta$ lie within their acceptance regions at 5% significance and $H_0$ cannot be rejected. We can be 95% confident that the real values of $\alpha$ and $\beta$ lie somewhere inside their respective acceptance regions. The result also illustrates that a 1% increase in the nominal interest differential leads to an approximately 0.93% change in the Yen/$ exchange rate. This comes quite close to the expected value of $\beta$, which was 1. An Alfa value of -0.03874 implies that the Yen would depreciate against the US dollar by approximately 0.039% if the US-Japanese nominal interest differential equals zero. Figure 4.2 on the next page shows the regression diagram for the US-Japan regression.
Figure 4.2 Relationship of the change in the US-Japanese exchange rate to US-Japanese nominal interest differential

The vertical axis in figure 4.2 shows the percentage change in the exchange rate Yen/$ and the horizontal axis shows the nominal interest differential. $s_{t+1}$ is frequently lower or higher than might have been expected at time $t$. On average, however, it seems like the relation between nominal interest differentials and exchange rate changes is roughly as predicted by the International Fisher Effect.

4.3 The regression results for United States-United Kingdom

The regressions from US-UK resulted in the following outcome:

R-squared = 0.035946.
Constant $\alpha = 0.005425$.
Variable $\beta = 0.441851$.

The acceptance region at a 5% significance level for $\alpha$ is $-0.00651 < \alpha < 0.017364$.
The acceptance region at a 5% significance level for $\beta$ is $-0.4272 < \beta < 1.310899$.

The R-squared for US-UK is very low. Only around 3.6% of the quarterly changes in the £/$ exchange rate can be explained by the nominal interest differentials. This leaves 96.4% of the quarterly exchange rate changes to be explained by other factors than the quarterly differences in the US and UK nominal interest rates.
The null hypothesis that $\alpha = 0$, $\beta = 1$ cannot be rejected since the hypothetical values of $\alpha$ and $\beta$ lie within their acceptance regions at 5% significance. The result also illustrates that a 1% increase in the nominal interest differential leads to a 0.44% change in the £/$ exchange rate. Thus, nominal interest differentials of 1% will only, on average, be offset by a 0.44% change in the British pound/US dollar exchange rate. Though, an estimated Alfa value of 0.005425 is in line with the predicted value of 0. Figure 4.3 shows the regression diagram for the US-UK regression.

![Figure 4.3 Relationship of the change in the US-UK exchange rate to US-UK nominal interest differentials](image)

**Figure 4.3** Relationship of the change in the US-UK exchange rate to US-UK nominal interest differentials

The vertical axis in figure 4.3 shows the percentage change in the exchange rate £/$ and the horizontal axis shows the nominal interest differential. The exchange rate changes are repeatedly lower or higher than might have been expected at time $t$, causing the low value of $R^2$.

**4.4 The regression results for United States-Canada**

The regression from US-Canada gave the following result:

R-squared = 0.013535.

Constant $\alpha = 0.006178$.

Variable $\beta = 0.157214$.

The acceptance region at a 5% significance level for $\alpha$ is $-0.00031 < \alpha < 0.012666$.

The acceptance region at a 5% significance level for $\beta$ is $-0.35253 < \beta < 0.666957$. 
The R-squared for US-Canada turned out to be exceptionally low. Only 1.35% of the quarterly changes in the C$/S$ exchange rate can be explained by the nominal interest differentials. The main part of the quarterly exchange rate changes between the C$/S$ would be better explained by other factors than the nominal interest differentials.

Here we can also reject the null hypothesis that $\alpha = 0$, $\beta = 1$ since the hypothetical value of $\beta$ lies outside the acceptance region at 5% significance. We must, however, be cautious in our conclusions due to the low $R^2$, which indicates that the model’s overall performance is low. The result illustrates that a 1% increase in the nominal interest differential leads to a 0.157% change in the C$/S$ exchange rate. This number is far from what’s predicted by the theory, which stated that the prediction errors would cancel out over time, resulting in a Beta value of 1. However, the Alpha value of 0.006178 can be considered to be insignificant different from zero. Figure 4.4 shows the graphical result of the regression from US-Canada.

![Figure 4.4 Relationship of the change in the US-Canadian exchange rate to US-Canadian nominal interest differential](image)

The vertical axis in figure 4.4 measures the percentage change in the exchange rate C$/S$ and the horizontal axis shows the nominal interest differential. The dots are widely scattered throughout the regression diagram revealing no observable pattern. These scattered observations also illustrate the low value of $R^2$, since the dots lie far off from the regression line.
4.5 The regression results for United States-Germany

The regression from US-Germany gave the following outcome:

R-squared = 0.013952.

Constant $\alpha = 0.00063$.

Variable $\beta = 0.198311$.

The acceptance region at a 5% significance level for $\alpha$ is $-0.01666 < \alpha < 0.017926$.

The acceptance region at a 5% significance level for $\beta$ is $-0.55826 < \beta < 0.954884$.

The R-squared for US-Germany is extremely low. Only 1.4% of the quarterly changes in the DM/$ exchange rate can be explained by the nominal interest differentials. This leaves 98.6% of the exchange rate changes to be explained by other factors. This might indicate that the nominal interest differential does not influence the exchange rate change linearly.

The H$_0$ that $\alpha = 0$, $\beta = 1$ can be rejected since the hypothetical value of $\beta$ lies outside the acceptance region at 5% significance. We must, however, be careful in our conclusions due to the low $R^2$, which indicates that the model’s overall performance is low. The result also illustrates that a 1% increase in the nominal interest differential, on average, leads to approximately a 0.2% offsetting change in the DM/$ exchange rate. The Alfa value indicates that the DM/$ exchange rate will change by 0.00063% when the US-German nominal interest differential equals zero. This is practically the same as none-change. Figure 4.5 illustrates the graphical result from the regressions US-Germany.

![Graph showing the regression result for US-Germany](image-url)
Figure 4.5 Relationship of the change in the US-German exchange rate to US-German nominal interest differential

The vertical axis in figure 4.5 displays the percentage change in the exchange rate DM/$ and the horizontal axis shows the nominal interest differential between the US and German nominal interest rates. By studying the regression curve one might get an explanation to the low value of the $R^2$. The observations form an U-shaped pattern, which could mean that the relationship between the nominal interest differentials and exchange rate changes would be best described by a quadratic function. Hence, testing for a linear relationship would be inappropriate. However, using an equation of the second degree to test for the relationship between the US-German nominal interest differentials and the DM/$ exchange rate changes lies outside the scope of this thesis.
Chapter 5
CONCLUSIONS

The purpose of this thesis was to describe the theory of the International Fisher Effect and test its empirical validity in the long run. Employing regression analysis to nominal interest differentials and exchange rate changes made this possible. The result from the regressions generated following conclusions.

The R-squared turned out very low for all country pairs. Because the $R^2$ is low for all studied country pairs, the nominal interest differentials should not be used to predict changes in future spot rate on a quarterly basis. This is also in line with the theory, stating that the nominal interest differentials are not a particularly accurate predictor of short-run movements in the spot rate of exchange. Rather, prediction errors tend to cancel out over time. However, the low $R^2$ is also indicating that the model’s overall performance is low.

The hypothetical values of $\alpha$ and $\beta$ all lie in their respective acceptance regions at 5% significance for US-Sweden, US-Japan and US-UK. Therefore, the null hypothesis that $\alpha = 0$, $\beta = 1$, cannot be rejected for these country pairs. This means that we can with 95% certainty say that the true values of $\alpha$ and $\beta$ lie somewhere in their respective acceptance regions. However, we can reject the null hypothesis for US-Canada and US-Germany, since the hypothesized values of $\beta$ for these country pairs lie outside respective acceptance region. Though, we must be careful in our conclusions due to the low $R^2$, which indicates that the model’s overall performance is low. Nevertheless, if we reject the null hypothesis for US-Canada and US-Germany we can conclude that the Beta-value cannot equal 1 for these country pairs, and therefore we cannot expect the nominal interest differentials to be fully offset by exchange rate changes for these pair of countries. This is also indicated by the low estimates of $\beta$ for these country pairs, with 0,157 for US-Canada and 0,198 for US-Germany. Another explanation for the rejection of the null hypothesis might be the low explanatory power of the R-squared, indicating that the model’s overall performance is low. The regressions for US-Canada and US-Germany resulted in R-squared of 1,35% respectively 1,4%. Such low estimates might indicate that the nominal interest differentials do not influence the exchange rate changes linearly and as a consequence, being a contributing cause
for the rejections of the null hypotheses. However, the estimates of $\alpha$ for the different country pairs resulted in values insignificant different from its hypothesized value of zero. Thus, on average, we could expect the exchange rate to remain unchanged when the nominal interest differential equals zero.

The estimates of $\beta$ resulted in seemingly low numbers for all country pairs compared to the expected value of 1, except for US-Japan. This result shows that the nominal interest differentials are not, on average, fully offset by exchange rate changes, as the theory predicted they would. The question asked for this thesis was if there is a tendency for nominal interest differentials to offset exchange rate changes? For US-Japan it is a clear tendency for the nominal interest differentials to offset exchange rate changes. For US-Sweden and US-UK this tendency is much weaker where approximately 50% respectively 44% of the nominal interest differentials are offset by changes in the exchange rates. For US-Germany and US-Canada this tendency is even lower, where approximately 20% and 16% of the nominal interest differentials were offset by exchange rates changes. Though, for the latter two, we cannot expect the nominal interest differentials to be fully offset by exchange rate changes due to the rejection of the null hypothesis.

The result from US-Sweden would be much more satisfying with the exclusion of some outliers present during the three first quarters of 1993. This indicates that the result is dependent upon the chosen time frames. Other time frames would likely to generate other outcomes. Thus, one should not expect the International Fisher Effect to consistently hold for US-Japan, or consistently to not hold for the other country pairs. The conclusion that can be drawn is that the International Fisher Effect seems to hold for US-Japan but not for the other country pairs during the investigated time period. In the case of US-Japan this would mean that investors investing purely in US 3-month certificates of deposit or Japanese 3-month interbank rate would have approximately average the same returns on their deposits because the short-term interest differentials would have been offset by exchange rate changes. Though, for the other country pairs it seems like one could have systematically profit from investing across the US and the foreign exchange market.

The low Beta values show that the exchange rate movements react to other factors in addition to nominal interest differentials. This might also indicate that the money markets are not truly internationalized. There are many restrictions that prevent capital from freely flowing across
borders to directly match nominal interest rate differentials. Examples of such factors are political risk, currency risk, transaction costs, taxes and psychological barriers. Though, one could assume factors like political risk to be insignificant for the investigated countries during the studied time frame. The exchange rate changes can also come about through some sort of activity between the goods and money markets, some real cross-border investment activity or change in trade patterns in the goods market, that all in all, still indirectly ensure nominal interest differentials are still, on average, offset by exchange rate changes. However, neither can the International trade assumed to be free. One could also expect slow adjustments in the goods markets and/or investments activities relatively to the money markets, why one might not see the effect on exchange rates by studying quarterly data.

An additional factor that might explain the low Beta values is the difficulty to determine the effect on exchange rate on a change in the nominal interest differential. According to the Fisher Effect can changes in the nominal interest differential be due to changes in either the real interest differential or relative inflationary expectations. These two possibilities have opposite effects on currency values. For example, a rise in the nominal interest in Sweden relatively to the USA, due to a rise in the real interest rate in Sweden relatively to USA will cause the value of the krona to rise relatively to the US dollar. On the other hand, if the nominal interest rises in Sweden relatively to the USA and this change in the nominal interest differential is caused by an increase in inflationary expectations in Sweden, the krona will depreciate relatively to the US dollar.

It is possible that the changes in the nominal interest differentials have contained changes in real interest differentials. The observations also shows that the exchange rate sometimes has changed in the opposite direction as predicted by theory, indicating a reaction to real interest differentials rather than relative inflationary expectations.

Also, if the domestic Fisher Effect and PPP do not hold, the International Fisher Effect will not hold. This means that inflation differentials need to offset exchange rate changes and the nominal interest rate differentials would approximately equal the expected inflation rate differentials. If not, the International Fisher Effect cannot be expected to hold.

It has been shown that the International Fisher Effect is only valid for US-Japan, but the results indicates that an investigation of other time periods would result in different outcomes.
A conclusion that can be drawn is that the International Fisher Effect seems to hold for some time periods and some country pairs but not for others. Therefore, no stable, predictable relationship between changes in the nominal interest differential and exchange rate changes can be assumed to exist.
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