A STUDY ON THE CAUSAL RELATIONSHIP BETWEEN RELATIVE EQUITY PERFORMANCE AND THE EXCHANGE RATE

The Swedish Case

Philip Barsk* and Magnus Cederlöf†

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Abstract

The question whether there is a causal relationship between exchange rates and equities is unresolved both in theory and empirically. The Flow theory postulates that exchange rates cause equity returns while the Stock theory suggests that equity returns cause exchange rates. Previous empirical studies have found mixed results although the relationship between these variables tend to be stronger in more developed economies and those studies that have found causality usually conclude that equity returns causes exchange rates. While most previous research has investigated the causality by looking at a single countries equity market, we use the return differentials between the market returns in two currency areas to test against the exchange rate. By employing the traditional test for Granger-causality we find that equity return differentials Granger causes exchange rates although not in the way that the theoretical background would predict. The results are however not independent of time-period since tests of the final six months in our data-set (the crisis period) generate different results. We conclude that for Sweden, a rise in domestic equity prices encourages investors to diversify away to bonds and foreign assets, more than they increase demand for domestic money. Moreover, the possible failure of including explanatory variables might have caused the different outcomes for the two time periods.

***Keywords**: Granger-causality, exchange rates, equity return differentials*

Tutor: Hans Tson Söderström
Examiner: Mats Lundahl
Discussants: Ellen Bernhardtson and Linnéa Graaf
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* 21419@student.hhs.se
† 21424@student.hhs.se

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1. INTRODUCTION

Equity prices and exchange rates are central economic variables that are constantly quoted in media and which tons of research has been devoted to. Although there is more or less consensus about how the levels of the exchange rate and equity prices, separately and in theory, can be explained, there is nowhere near such consensus on whether there is a causal relationship between the two. Theory on the subject can roughly be divided into the traditional Flow-theory and the portfolio approach or the Stock theory.

The Flow theory is in the literature thought of as the traditional approach to explain a causal link between exchange rates and equity performance. The theory states that exchange rates cause equity returns through its effect on companies' future cash flows and its net foreign assets. A depreciation of a country's currency would according to the Flow theory have a positive effect on that country's equities. One reason for the positive effect on companies' cash flows from currency depreciation is the fact that companies receive more Swedish kronor for every unit they sell abroad. Another reason is the positive balance sheet effect, in terms of Swedish kronor, that would occur in the event that a company has net foreign assets.

The Stock theory explains why equity returns causes exchange rates. According to the Stock theory, equity prices cause exchange rates since it alters the demand for money. If a country's equity market rises, people's wealth increases. The wealth increase is assumed to have a positive effect on money demand, which is, given a constant money supply, assumed to lead to a higher interest rate and a currency appreciation.

In addition to these hypotheses, there is also theory that postulates that exchange rates and equity prices are not causally related. In harmony with the disagreement on the theoretical level, previous studies of a possible causal relationship between these variables has shown varied results. Apart from the fact that possible causal relations may vary depending on country, currency regime, time-period etc., the fact that different methods and models for testing for causality have been used might also explain the divergent results. However, a general conclusion that unites many of the previous studies is that a causal relation is more likely to be found in advanced economies and the causality between the exchange rate and equity returns tend to be uni-directional, running from equity returns to exchange rates, in line with the Stock theory.

This study applies the standard test for Granger-causality, designed by the Nobel laureate Clive Granger. Granger-causality is economists' favorite notion of causality and what the bulk of previous research on causality between exchange rates and equity returns has used. Previous research has almost exclusively used a model with only one country's equity market which has been tested against the relative price of

another currency. Although the results of such tests give one an understanding of possible causal links between an exchange rate and an equity market, such tests overlook the fact that the theoretical background to a great extent assumes relative variables. An exchange rate is by definition the relative price of two currencies. We argue that the exchange rate should be tested against a relative variable for equity returns in order to enable one to empirically test the theory. Suppose that Swedish equities rise, the Stock theory would then predict the Swedish krona to appreciate against other currencies. But if the equity markets in other currency areas also perform very well the effect on the exchange rate is ambiguous. The Stock theory would in fact predict that the Swedish krona would depreciate against a given country's currency in the event that equities perform even better in that country. This highlights the rationale behind using a relative performance measure for equities when testing theory on causality between exchange rates and equity returns. Knowledge about a possible causal relationship would be useful for investors, companies and other market actors that are affected by these variables.

This paper examines whether there is Granger-causality between a bilateral exchange rate for the Swedish krona and Swedish equity returns relative to equity returns in the other currency areas. To be able to draw as general conclusions as possible and as a check of the robustness of our results tests are made on the SEK/USD exchange rate and SEK/EUR and SEK/GBP equivalents. These exchange rates are tested against corresponding relative equity performance. The observations are made up of daily observations from January 2001 till February 2009.

Previous research indicates that exchange rates and equity performance are casually related in advanced economies. Most studies, including a study on Sweden in the nineties, have found that the causality goes from equity performance to exchange rates. Our hypothesis is that we will find a causal relationship in all three cases and that the causality will be uni-directional, running from relative equity returns to exchange rates in agreement with the Stock-theory.

Section 2 goes through the theoretical background to familiarize the reader with the topic and the conflicting theoretical explanations for the relationship between equity markets and exchange rates. Section 3 presents a selection of previous research and outlines what we aim to contribute with, section 4 describes the data in this study and section 5 treats the methodology. In section 6 we present the empirical results, section 7 discusses the results and section 8 concludes.

2. THEORETICAL BACKGROUND

The most common theoretical approaches to this issue are the *Stock theory* (which explains how equity prices cause changes in exchange rates) and the *flow theory* (that suggests an explanation for why exchange rates cause equity prices), but there are also explanations to why exchange rates and equity prices may move according to a certain pattern relative to each others despite an absence of causality between them.

2.1 AN EXOGENOUS INCREASE IN DOMESTIC OUTPUT

One explanation for the co-variation of equity prices and exchange rates can be obtained by considering an exogenous change in domestic output. The uncovered interest parity condition postulates a negative relation between domestic output and the exchange rate, while equity prices are positively related to output.

As described by Krugman and Obstfeld (1997, Chapt. 16), the uncovered interest parity condition is based on the assumption that investors require the same expected return on domestic and on foreign currency deposits. The authors present the following equilibrium equation:

EQUATION 1

$$R = R^* + (E^e - E)/E$$

where R is the interest rate on the domestic currency deposits, R* is the interest rate on foreign currency deposits, E is the exchange rate (units of domestic currency per unit of foreign currency) and E^e is the expected future exchange rate. We assume E^e and R* to be given. If the interest rate on domestic currency deposits decreases, an offsetting immediate depreciation of the domestic currency is required in order to keep the expected return on domestic currency deposits constant. Provided that E^e has not changed, such a depreciation results in an expected future appreciation of the domestic currency, so that the expected return on both currencies are equalized.

Krugman and Obstfeld (1997) also state that in equilibrium, real money supply (M^S/P) must equal real money demand L(R,Y). When the interest rate falls, or when domestic output goes up while money supply remains constant, real money demand rises. The increase in domestic output causes an increase in real money demand due to the fact that a larger number of transactions will take place in the economy. This drives up the domestic interest rate. Given that E^e and R* are unchanged, equation 1 makes clear that E must fall, i.e. the domestic currency appreciate, as a result of the higher output.

Equity prices are in general defined as the present value of future cash flows (Stavárek 2005). Based on the definition in Bodie et al. (2008, p. 630-631), equity prices can, given that $k_e > g$, be represented by *equation 2*, where FCFE denotes cash flow available to equity holders, k_E denotes the cost of equity and g is the long-term growth rate in FCFE.

EQUATION 2

$$Value = \frac{FCFE}{k_E - g}$$

Besides from having a positive effect on the value of the domestic currency, a rise in domestic output can also be assumed to give rise to higher cash flows for companies, which in turn drives up equity prices. On the other hand, the increase in the interest rate that comes as a result of the higher domestic output pushes up k_E, which has a negative effect on equity prices. However, if we assume that the positive effect on equity prices is dominant, the uncovered interest parity condition in combination with the equity pricing formula (*equation 1*) together describe how an exogenous change in domestic output, working via the interest rate and FCFE, affects both the exchange rate and equity prices without postulating any direct causality between the two variables.

2.2 THE STOCK THEORY

According to the Stock theory, the exchange rate is determined by individuals' willingness to hold domestic vs. foreign assets. Within the Stock theory we distinguish between two different approaches, the monetary approach and the portfolio balance approach. The logic is the same for the two approaches, but the first is limited to deal with the role of money, while the latter takes on a broader view as it takes other asset types into consideration as well (Krueger 1983, p. 81).

2.2.1 THE MONETARY APPROACH

According to Rosenberg (2003, pp. 171-172), the monetary approach treats the demand for and supply of money as the main determinants of exchange rates, and says that expansionary monetary policies, providing excess money supply, push down the value of the currency as individuals increase their holdings of foreign assets. Krueger (1983, pp. 57-58) further points out that when citizens of a country consider themselves possessing excess amounts of money, the imports of goods, services and assets will increase relative to exports. This effect can be explained by the interest parity condition; as the interest

rate goes down, responding to increased money supply, the currency depreciates so that an appreciation to E^e can be expected in the future.

The monetary approach is less comprehensive and complete than the portfolio-balance approach, and widely regarded as insufficient to explain exchange rate determination, due to the failure of taking other explanatory variables into consideration (Rosenberg 2003, p. 171). Therefore, the portfolio-balance approach better serves as a basis for our analysis.

2.2.2 THE PORTFOLIO-BALANCE APPROACH

According to Krueger (1983, p. 87), the portfolio-balance approach focuses on movements in people's willingness to hold domestic vs. foreign money and securities, and the exchange rate balances individuals' willingness to hold foreign and domestic assets, respectively.

An exogenous rise in domestic equity prices results in higher wealth, encouraging investors to demand more money, which raises domestic interest rates so that the domestic currency appreciates (e.g., Stavárek 2005, and Granger et al. 2000)[1].

Stavárek (2005) also outlines a direct effect through which equity returns lead the exchange rate. As the value of domestic assets increases, investors increase the weight of domestic assets in their portfolios at the expense of foreign assets. In order to enable this change in holdings from foreign to domestic equities, investors have to sell foreign and acquire domestic currency. Therefore, an increase in equity prices causes an instantaneous appreciation of the domestic currency.

In conclusion, the Stock theory provides an explanation for a causal relation running from equity prices to exchange rates, where an exogenous rise in domestic equity prices generates an appreciation of the domestic currency.

2.3 THE FLOW THEORY

The Flow theory is often referred to as the traditional framework for explaining the relation between exchange rates and equity returns (Granger 2000). Like most other studies of Granger-causality between exchange rates and equity returns, we base our description of the Flow theory on Aggarwal (1981). If the domestic currency depreciates, the country's international competitiveness is improved. This infers enhanced prospects for future cash flows for domestic firms that are relying on exports, import competing production or foreign operations. Two reasons for the enhancement can be identified. One is that the

[1] For a deeper discussion, see Krueger (1983, pp. 81-91).

prices of exports and import competing goods in terms of the domestic currency rise, allowing domestic companies to **increase revenues** either by utilising these higher prices or by increasing volumes by lowering their prices in terms of foreign currency[2]. The other reason is that the value of net foreign assets increases in terms of domestic currency when the domestic currency depreciates. This generates a **balance sheet gain** if net foreign assets are positive.

Companies dependent on imported goods or inputs, on the other hand, will face higher costs and less competitiveness compared to foreign actors. Hence, cash flows will get smaller and equity prices will fall. Similarly, a balance sheet loss will hit those companies that have net foreign liabilities.

However, the increased foreign trade should result in that domestic firms on the whole become better off with a depreciation of the domestic currency.

To conclude, an appreciation of the Swedish krona shall, due to the effect on revenues, lead to lower equity prices. In what direction the balance sheet effect would work, i.e. whether Swedish companies possess positive or negative net foreign assets, is hard to tell, due to the complex and globalised ownership situations. However, this fact in itself makes the issue less relevant to consider, as it implies significant difficulties for investors to assess how exchange rate movements affect companies' balance sheets.

3. PREVIOUS RESEARCH

The first study related to this area of research was made by Franck and Young (1972); they investigated the impact of more volatile exchange rates, following the financial crises at the time, on U.S. companies. They set out to examine whether there was any relationship that could have policy implications for companies. By using simple regression and correlation techniques, they found no significant interaction between these variables that companies can make use of. A more relevant study, and often cited piece of work, was made by Aggarwal (1981). Aggarwal looks at the correlation between the USD exchange rate and U.S. Stock indices, using monthly observations, during 1974-78. He defines the exchange rate as the USD against a trade weighted currency basket containing the currencies of the United States' forty six largest trading partners. Equity prices are represented by three U.S. equity indices. He finds a positive correlation in line with the flow theory, that exchange rates lead equity prices.

[2] While exchange rate changes have a direct effect only on companies involved in exports and imports, companies acting solely on the domestic market are affected as well. If, for instance, a depreciation of the domestic currency results in higher prices of imported production inputs, then companies that formerly have acquired these inputs from abroad will to a greater extent turn to domestic producers. This makes the prices of domestically produced inputs go up as well.

Before the 90's, studies of the relation between exchange rates and equity prices were limited to the statistical methods available at the time. Stavárek (2005) points out that Bahmani-Oskooee and Sohrabian (1992) were among the pioneers when it comes to make use of cointegration and Granger-causality tests to investigate a possible causal relation between exchange rates and equity prices. The authors used monthly data to examine the relation between the USD effective exchange rate and the S&P 500 index for the time period 1971-68 and conclude that there was bidirectional causality, which means that the causality goes in both directions.

Overall, most of the research that has been made on the relation between exchange rates and equity prices has focused on the US and Southeast Asia. Pan et al. uses daily data to examine the dynamic linkages for seven East Asian countries, including Hong Kong, Japan, Korea, Malaysia, Singapore, Taiwan, and Thailand, for the time period; January 1988 and October 1998. They find a significant causal relation running from exchange rates to equity prices for Hong Kong, Japan, Malaysia, and Thailand before the 1997 Asian financial crisis. They also find a causal relation running from equity prices to exchange rates for Hong Kong, Korea, and Singapore. A rise in Equity prices causes the currencies to appreciate. During the financial crises, when both the equity prices and the value of these countries currencies fell freely, no country showed any significant causal relation from equity prices to the exchange rate. However, they all, with the exception of Malaysia, showed a causal relation from exchange rates to equity prices. The authors point out that a crisis, such as the Asian financial crisis of 1997, may alter the nature of equity price-exchange rate relations. The results are obtained in spite of the fact that none of these economies, with the exception of Japan, have an entirely free floating exchange rate arrangement, something that one could suspect would dampen any linkages.

Doong et al. (2005) use weekly data to examine the relation for Indonesia, Malaysia, the Philippines, South Korea, Thailand, and Taiwan between 1989 and 2003. They find bidirectional causality between exchange rates and equity prices in Indonesia, Korea, Malaysia, and Thailand. Further, with the exception of Thailand, equity prices in the countries under study are negatively related to the exchange rate, hence, a depreciation of the currency is associated with a fall in equity prices. Granger at al. (2000), similarly to Pan et al. sets out to investigate if there is any causal relationship between exchange rates and equity prices in their free fall during the Asian financial crisis. Using daily data, they find that most countries can be described by the portfolio approach, that equity prices lead exchange rates, or there is feedback interaction or bidirectional causality (either market can take the lead). Further, the authors underline that although they find statistical relationships, it is difficult to interpret the results since they can be generated from other structural relations such as the interest parity condition or IS-LM related policies. As an

example they point out that a recessionary shock or other unfavourable information on a country can make both the country's equity market and currency fall. In addition to only incorporating exchange rates and equity prices to the model, the authors include the US equity market, the FEDs fund rate, the respective countries interest rates and the difference between these rates. The US equity market is included in the model since research indicates that it has significant influence over the Asian equity markets and the interest rates are included because they mirror economic prospects and are very much related to both exchange rates and equity prices.

Stavarek (2005) investigates the issue by testing the short- and long term relation between exchange rates and equity prices in the US as well as in four old EU countries and four new members of the EU, using monthly data. Stavarek divides his data set into two time periods; 1978-1992 includes only developed countries and 1993-2003, including all countries. The results show that causality between the variables is strongest in countries with more developed foreign exchange markets. Further, the short- and long term causality is more powerful in the later time period, suggesting that as capital markets has become more integrated, and capital controls have been abolished, the link between exchange rates and equity prices has become stronger. However the direction of causality is not uniform but differs between countries. The author also concludes that no relation can be determined between the variables in the four new EU countries in the study. Stavárek's explanation to this is that these countries equity markets are not aligned with their respective real economies and that they do not attract international investors to any greater extent.

Fazel (2005) is critical towards those that argue for a causal relationship between exchange rates and equity prices. Fazel recognizes that a causal relation can be true during certain circumstances at shorter time periods but that there is no stable long term causal relationship between the variables. Fazel argues that both exchange rates and equity prices are endogenous variables and that their long-term relationship is dependent on the exogenous variable that causes exchange rates and equity prices. The exogenous variable could be the interest rate. The interest rate has two components, the real interest rate and inflation. Fazel argues that whether a change in the interest rate is caused by a change in inflation or a change in the real interest rate will have different effects on the exchange rate and equity prices. Hence, the relationship between exchange rates and equity prices are dependent on the cause of changes in the nominal interest rate and that cause is unstable over time. Fazel hypothesizes that there is no stable relationship between equity prices in the Euro zone and the Euro. By employing simple regression analysis he founds that the variables are not correlated.

While most previous research has studied the relationship between equity prices and bilateral exchange rates by looking only at a country's equity price index and the exchange rate and how these time series interact, Ajayi et al. (1998) study the relationship between these variables by looking at the difference in equity returns between two countries and their respective exchange rate. The authors employ standard Granger-causality tests on seven advanced economies and eight emerging Asian economies. Causality is found; running from equity returns to exchange rates, for all advances economies but the results for the emerging economies is mixed. The authors conclude that their results can be explained by a higher level of integration between equity- and exchange markets in the advanced economies compared to the emerging economies. The study is performed with daily as well as with weekly data; both data sets generate the same results in the advanced economies, although daily data generate stronger results. However, the results differ depending on data frequency in the case of the emerging economies.

To our knowledge, the only study of Granger-causality between these variables that has been made on Sweden was performed by Hatemi-J and Irandoust (2002). They examined the causal relation between the OMX PI index and the nominal effective exchange rate as measured by the TCW index. They used monthly observations over the time period 1993-1998, i.e. the first years after the floating currency regime was introduced in Sweden. By using the relatively new Granger non-causality test, developed by Toda and Yamamoto (1995), they find that the causality is unidirectional and runs from equity prices to the exchange rate. The SEK tends to appreciate when equity prices go up.

3.1 OUR CONTRIBUTION

This essay studies the Granger-causality between relative equity returns and exchange rates in line with Ajayi et al. (1998). We aim to shed light on whether there is a causal relationship between the exchange rate for the Swedish krona and three other currency areas' currencies and how well the respective currency areas' equity markets perform in relation to the Swedish equity market. Although the bulk of previous research on this relationship has not used relative equity returns, we argue that it is necessary to use relative returns. As explained in the introduction, a study that uses absolute returns is not able to draw any reasonable conclusions regarding whether the findings match the theoretical background. The theoretical background assumes that both variables are relative.

The Hatemi-J and Irandoust (2002) study on Sweden that investigated the causal relation between equity returns and exchange rates did not use relative equity returns. Further, the data set that was used was monthly observations from 1993 till 1998. We want to contribute to the research on this topic by using daily observations from 2001 till 2009 of relative equity returns and exchange rates.

4. DATA AND GRAPHICAL ANALYSIS[3]

The data set employed in this study consists of daily observations of the exchange rate between the Swedish krona and the three currencies that Sweden is engaged in most trade with, the Euro, the USD and the GBP (KIX-index). In addition, the daily return differentials between comparable equity indices related to each currency is included. The equity indices are chosen so that they represent the broad performance in the respective markets and they are denominated in their respective currencies. Moreover, the differentials between the respective central bank rates are included in the models as a control variable. All data are collected from Thomson's Datastream. The Swedish equity market is represented by the OMX Stockholm index which includes all equities listed on the Nordic exchange in Stockholm. The Euro Zone equity market is represented by the S&P Eurozone Broad Market Index, the British equity market is represented by the FTSE All-share index (excluding multinationals) and symbolizing the U.S. equity market is the S&P1500 Super Composite index. We use the equity indices daily closing prices and the time difference with the U.S. market is disregarded (we do not lag the S&P1500 Super Composite). The exchange rates that we use are collected from banks at 9:30 A.M (Swedish time) and these are matched with the previous day's equity prices.

Previous research has used varied observation frequencies when studying the causal relationship between exchange rates and equity performance. The most common frequencies that have been tested are daily and monthly. The choice of frequency is simply a question of ones belief on the lead and lag time. More recent studies tend to use daily observations and studies with daily observations are also the ones that to the greatest extent have found Granger-causality. Granger et al. (2000) point out that daily data is necessary in order to capture capital movements.

Figure 1 below illustrates the return difference between OMXS and S&P1500 and the exchange rate between the SEK and the USD. In 2001 Swedish equities were performing worse than U.S. equities and the SEK depreciated. In 2002 and 2003 Swedish equity prices continued to perform less well than its US equivalents, however, the SEK appreciated significantly. In 2004 it is hard to discern any particular pattern but in 2005, when Swedish equities performance was much stronger than the U.S. equivalents, the SEK depreciated significantly. The development in 2006 was characterized by an appreciating SEK, while Swedish equities performed relatively better overall though there was no clear trend. Both 2007 and 2008 are characterized by extreme volatility in the relative equity performance variable while the SEK appreciate steadily until mid 2008, when it started to depreciate significantly. From the chart one cannot

[3] The charts in this section have the exchange rate on the right hand axis and the return differential on the left hand axis. The returns differentials are calculated by indexing all indices so that they start at 100 (2001-01-02=100, hence, the left hand side axis represent percentage point differentials between the indices.

make any inference about whether there is a causal relationship between these variables. The way these time series move show no clear pattern throughout the period. What one can detect is periods of time with a clear negative, or positive, correlation between the variables. It is not feasible to distinguish movements on a daily basis why it is impossible to get an idea about any day-to-day pattern.

FIGURE 1

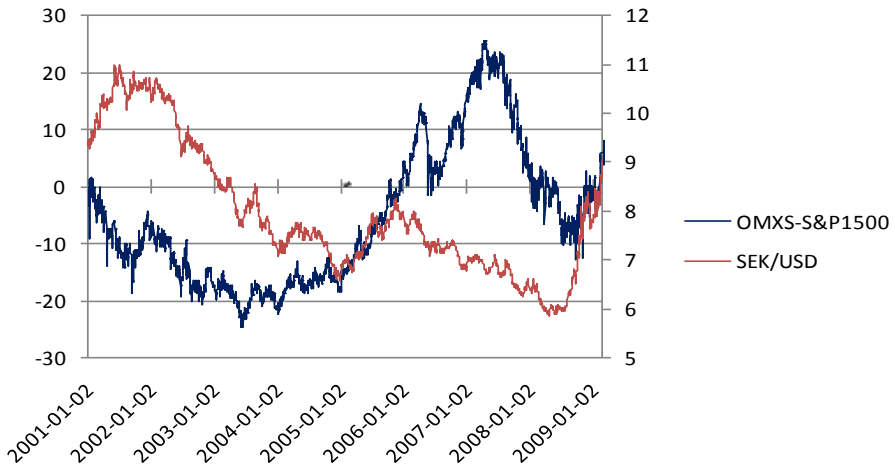


Figure 2 describe the return differential between OMXS and FTSE All-share and the SEK/GBP exchange rate. As in the US case above, there was a clear negative relationship between these variables in the greater part of 2001; Swedish equities were performing worse than its British equivalents while the SEK depreciated. From 2002 till 2006 one can not distinguish any particular pattern. In 2007 the exchange rate does not move much while Swedish equities continue to outperform the British equivalents and in 2008 the SEK appreciated significantly while returns do not differ much between the respective markets. As, in the U.S. case we cannot detect any clear correlation between the exchange rate and the equity return differential throughout the period.

FIGURE 2

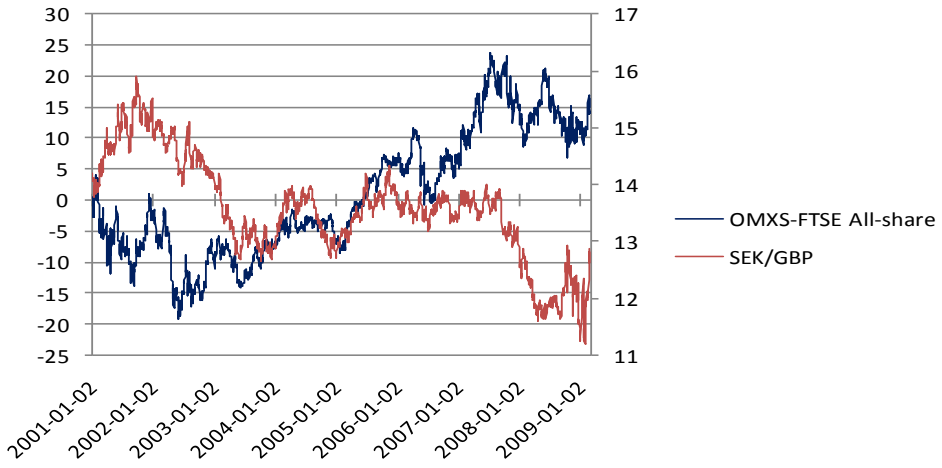
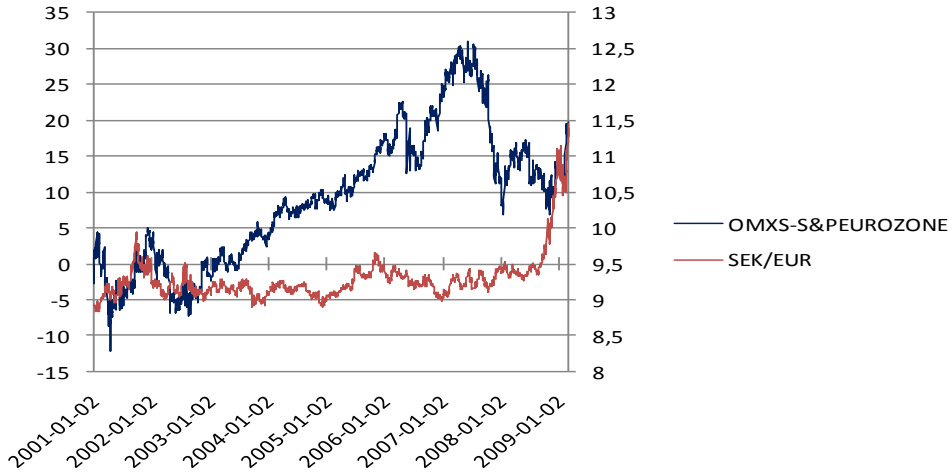


Figure 3 illustrates the equity return differential between OMXS and the S&P Euro Zone index and the SEK/EUR exchange rate. We can see from the chart that the exchange rate did not move much during the greater part of the time period. Swedish equities did however perform considerably better than European equities during this time period. However, from mid-2007, European equities began to catch up and in mid-2008 the SEK started to depreciate radically. Again, we cannot draw any general conclusion about the relationship between these variables.

FIGURE 3



5. METHODOLOGY

Research on the causal relationship between equity prices and exchange rates has been conducted with various methods. However, previous research has almost exclusively relied on Granger causality in one way or another. Economists tend to use the traditional approach, designed by Granger (1969), whereas econometricians have begun to use more advanced tests such as the Granger non-causality test developed by Toda and Yamamoto (1995). Further, and as mentioned above, most studies do not use a relative equity price variable but look only at one equity price index. Also, some studies look at the real exchange rate and/or control for variables such as the interest rate while others do not. These differences in tests and models used impose difficulties when comparing results and make one think twice before deciding which test to use and which variables to include.

This study uses the traditional test for Granger causality with, if necessary, preceding tests for cointegration to arrive at the proper model for conducting the test. A specification of the variables will follow below in section 6.1.

5.1 INTRODUCTION TO GRANGER CAUSALITY

If one looks up the word causality in a dictionary one will read that it is the relation of cause and effect. The concept can seem trivial but it is actually not as crystal clear as it might appear. One can say that causality is a philosophical concept which has no correct definition. It is an issue that has tackled the minds of thinkers such as Aristotle and the Scholatics. David Hume was the first philosopher to treat causality in a macroeconomic context, one of his more famous works is the quantitative theory of money which states that the stock of money in relation to the stock of available goods causes the price level (Hoover, 2001, p. 2). Since Hume's days the debate on causality and what it is has continued but the tools and techniques to investigate the matter has become ever so sophisticated. Today, according to Hoover (2001 p. 150), Granger-Causality is economist's favourite notion of causality.

Granger (1969) suggests a data-based technique for enabling one to decide whether two variables are casually linked. Granger (1980) states that attitudes towards causality are widespread, there are those that take the stance that it is impossible to define causality while others believe that everyone has their own definition of what causality is. The differing perspectives make it difficult to come up with a generally acceptable definition. Granger has proposed a definition which has found, more or less, general support. The definition rests on the axiom that the past and present may cause the future, but the future cannot cause the past. Further, the definition assumes that the causing variable adds explanatory power to an event in addition to all other knowledge in the universe.

From Granger (1980), the general definition is that: Y_n is said to cause X_{n+1} if $P(X_{n+1} \in A \mid \Omega_n) \neq P(X_{n+1} \in A \mid \Omega_n - Y_n)$, for some A, where X_n and Y_n are time-ordered sets of variables and Ω_n is the set of non redundant information available at time n. That Ω_n does not include any redundant information implies that if some variable Z_n is functionally related to one or more other variables, in a deterministic fashion, then Z_n should be excluded from Ω_n.

For causation to occur, the causing variable (Y_n in the definition above) needs to have some unique information about what value the variable it is causing will take. The definition above is not operationally possible. Practical implementation demands a limited data set, a limited number of lags and only a couple of variables. These constraints do imply some difficulties. Granger (1980) points out that data inadequacy can cause problems, for instance, if data is not gathered frequently enough. If a causal relation is evident on a weekly basis but data is recorded on a monthly basis then the causal relation will appear to be instantaneous and it will be impossible to determine whether there is a causal relationship or if both series have a common cause. Sorensen (2005) states that instantaneous causality occurs when the time series are correlated, which economic time series often are. If one then finds granger causality in one direction, one may feel that the case for "real" causality is stronger. Further, according to Granger (1980), the problem of missing variables can lead to misinterpretation of one's results, an apparent causation can be proved to be spurious once additional variables are added. Related to this is the possibility of unobservable variables, Granger (1980) exemplifies this with the thunder lightning example; that X causes both Y and Z but the causal lag is shown from X to Y, then from X to Z. If X is not observed, Y will appear to cause Z. Hence, sometimes the missing variable will be available and, when added to the information set, the leading indicator (Y in the thunder and lightning example) will no longer appear to cause. When the missing variable is unobservable one can not tell if a variable is a cause or only a leading indicator. Further, if the time that an event is recorded deviates from when an event occurs, this needs to be taken into account in interpretation.

Granger (1980) highlights the importance of sophistication of the analysis used in deciding proper causal relations to test and that interpretation must be conducted with care. Granger (1988) further states that extra knowledge is useful when interpreting the results, such as economic theory. Sorensen (2005) states that "Granger causality measures if one thing happens before another thing and helps predict it – nothing else".

5.2 THE GRANGER-CAUSALITY TEST

The test for Granger causality involves estimating the following pair of regressions:

$$Y_t = \alpha_0 + \sum_{i=1}^{m} \alpha_{1i} Y_{t-i} + \sum_{i=1}^{m} \alpha_{2i} X_{t-i} + u_{1t}$$

$$X_t = \beta_0 + \sum_{i=1}^{m} \beta_{1i} X_{t-i} + \sum_{i=1}^{m} \beta_{2i} Y_{t-i} + u_{2t}$$

A variable X(Y) Granger causes a variable Y(X) if the error variance of a regression of Y(X) on its own past history and on the past history of X(Y) is statistically significantly lower than the error variance of a regression of Y(X) on its own past history alone. Hence, Granger-causality stresses the patterns of correlation found in empirical data (Hoover 2001 p. 132). In practice, this is done by an F test[4].

According to Gujarati (2003 p. 697) we can distinguish between four different outcomes of the test:

1. Unidirectional causality from Y to X.
2. Unidirectional causality from X to Y.
3. Feedback or bilateral causality.
4. Independence.

The Granger causality test assumes that the variables X and Y are stationary. Moreover, the number of lags is an important question that affects the result of the test. If one finds that the variables are integrated of order one, denoted I(1), which is expected for many important macroeconomic variables, a test for cointegration must be performed to decide whether we need to proceed with a Vector Error Correction Model or not (Engle and Granger 1987). Cointegration would imply that a linear combination of the two time series, integrated of order one, is stationary. In addition, this would imply that there is a causal relation between the variables (Granger 1988). It is described below how these issues are handled in this study.

[4] An unrestricted (UR) regression and a restricted (R) regression are formed. The latter does not contain the variable(s) which we want to test whether they have significant explanatory power. The F statistic is calculated from:

$$F(m, n-K) = \frac{(RSS_R - RSS_{UR})/m}{RSS_{UR}/(n-K)}$$

where RSS is the residual sum of squares, m is the number of variables that are excluded in the restricted regression, n is the number of observations and K is number of parameters in the unrestricted regression. If the computed F value exceeds the critical F value, the null hypothesis, H_0: $\beta_1 = \beta_2 = \ldots = \beta_m = 0$, is rejected.

5.2.1 STATIONARITY

This section is entirely based on Gujarati (2003, pp. 797-805). A process is considered *stationary* if its mean equals zero, it has constant variance, and the covariance of two time periods is constant irrespective of which time periods are used and the distance between them. The process is said to be *weakly stationary* if the two first conditions are fulfilled but the covariance between two time periods depends on the distance between the time periods, but not on when it is calculated. If the process is stationary around a trend, it is said to be *trend-stationary*.

A common example of *non-stationary* time series is the random walk model (RWM). A stationary time series that is situated below its mean will have a larger probability of increasing than decreasing as its next move. For a RWM, the probability of an increase is always equal to the probability of a decrease, irrespective of whether it is found above or below its historical mean value. Thus, it has the same mean as a corresponding stationary series, but its movements along its mean is drawn-out so that it crosses the mean value less frequently. RWM may appear with or without drift.

In some cases, taking first difference of a RWM can make it stationary. In that case the series is integrated of order 1, denoted as I(1). If one has to take first difference twice to obtain a stationary series it is integrated of order 2, I(2), and if we have to take first difference d times the series is an I(d) process. A series that is integrated of order 0 is stationary.

5.2.2 LAGS

It is stated in section 5 that the number of lags affects the result of the Granger-causality test. This is of course related to the problems that can occur with the test for Granger-causality, as described in section 5.1, in the event that the point in time that a causal relationship occurs and the frequency of the data gathered deviates. From the definition of Granger-causality, the cause cannot occur after the effect, which implies that the lag is either positive or zero, zero implying instantaneous causality. Granger (1988) argues that instantaneous causality does not occur in macroeconomics but that the possibility of missing variables cannot be ruled out. This implies that the test for Granger-causality assumes positive lags.

5.2.3 CAUSALITY AND COINTEGRATION

As stated above, two variables are said to be cointegrated if they are both non-stationary, e.g. I(1) processes, but a linear combination of the variables is stationary, I(0). According to Gujarati (2003, p. 822) that implies that the linear combination of the time series cancels out the stochastic trends in the

variables and that there is a long-term or equilibrium relationship between the variables. Granger (1988) states that this can be explained by that there exists a constant, alpha, such that $z_t = x_t - \alpha y_t$, is I(0).[5]

6. EMPIRICAL RESULTS

6.1 VARIABLE DESCRIPTION

To obtain equity returns, we transform the equity indices into their natural logarithmic form, which we then take in first-difference, i.e. each observation less the previous observation. This approximately equals the percentage changes. We then subtract the percentage return of each respective foreign index from the return on the OMXS index. In that way we obtain the percentage return on Swedish equities relative to the percentage return of each foreign equities market.

As exchange rate variables we use the logarithmic form of bilateral exchange rates between the Swedish Krona (SEK) and the foreign currencies under consideration, defined as units of SEK per unit of foreign currency. By using the log form, we circumvent any potential problems stemming from heteroscedasticity (Wooldridge 2009, p. 191), which in other case could invalidate the usual t and F statistics (Wooldridge 2009, p. 432).

The interest rate plays a central role in many theories dealing with the relation between equity prices and exchange rates. Therefore, movements in the interest rate that appears as exogenous in our system, i.e. which are not caused by changes in equity prices, might alter the exchange rate without being driven by equity prices. This can make the causality between exchange rates and equity prices appear as weaker than it is. Thus, it is adequate to control for exogenous changes in the interest rate. For that reason we include relative changes in the different markets' central bank interest rates. These variables, which we henceforth refer to as the *interest variables* and denote by R (with the superscript telling to which central

[5] Granger (1983) has shown that if xt and yt are cointegrated they will then be generated by an error correction model like the one below or otherwise the model will be miss specified.

$$Y_t = \alpha_0 + \delta_1 (Y_{t-1} - \gamma X_{t-1}) + \sum_{i=1}^{m} \alpha_{1i} Y_{t-i} + \sum_{i=1}^{m} \alpha_{2i} X_{t-i} + u_{1t}$$

$$X_t = \beta_0 + \delta_2 (Y_{t-1} - \gamma X_{t-1}) + \sum_{i=1}^{m} \beta_{1i} X_{t-i} + \sum_{i=1}^{m} \beta_{2i} Y_{t-i} + u_{2t}$$

bank's interest rate the Swedish interest rate is set in relation), are calculated by taking the first difference of the difference between the Swedish Repo Rate and the Euro Short Term Repo, the US Federal Funds Rate and the UK Clearing Banks Base Rate, respectively. By including the relevant interest variable in each regression we can discern the effect of monetary policy shocks from the causality between relative equity returns and exchange rates.

6.2 TESTS OF STATIONARITY

To ensure that all variables are stationary, we conduct the ADF test[6] on each variable, with up to five lags. We use the Akaike Information Criterion[7] (AIC) to decide which number of lags that are appropriate to

[6] To test whether a time series contains a unit root or not, i.e. if it is stationary, a Dickey-Fuller (DF) test can be used. It is based on the following equation

$$Y_t = \rho Y_{t-1} + u_t \qquad -1 < \rho < 1 \tag{1}$$

u_t is a white noise error term. If $\rho = 1$ (1) becomes a non-stationary stochastic process, or more narrowly a random walk with drift. We can rearrange (1) so that

$$\Delta Y_t = \delta Y_{t-1} + u_t \tag{2}$$

where Δ represents the first-difference and $\delta = (\rho - 1)$.

The DF test employs the null hypothesis: $\delta = 0$, that is, the series is non-stationary. Under the null hypothesis, the estimated *t* value of δ follows the Dickey-Fuller type of distribution. (Dickey and Fuller 1979)

If u_t is autocorrelated an augmented Dickey-Fuller (ADF) test can be used. In this test (2) is extended to contain one or more lagged values of the dependent variable as explanatory variables. The reason for that is that if the error term is autocorrelated, the series will change between values above and values below zero either more or less frequently than if it was uncorrelated. Including more lags tends to even out the rounds of observations above or below zero, erasing the bias in the error term. The test is carried out in the same way as the DF test, i.e. by testing if the null hypothesis of $\delta = 0$ can be rejected or not. The regression is as follows:

$$\Delta Y_t = \beta_1 + \delta Y_{t-1} + \sum_{i=1}^{m} \alpha_i \Delta Y_{t-1} + \varepsilon_t \tag{3}$$

where ε_t is a pure white noise error term. The number of lags of the dependent variable that shall be included can be tested empirically, by checking which model has the best fit. (Elliot et al. 1996)

[7] AIC is a measure of model fit, and can be used to test which model is most appropriate. For instance models with different lag lengths can be compared. The lower the AIC value, the better fitted is the model. The equation we use throughout this paper is the following:

$AIC = 2k + n(\ln(RSS / n))$

include in the ADF test. The equity return variables are all stationary, which was expected since they are already differentiated once from their levels[8]. The case is the same with the interest variables. All of the exchange rates are, on the other hand, non-stationary. Therefore we differentiate them and that turns out to make them stationary. As a result we henceforth use the first-difference form of the exchange rates, which implies that we deal with percentage changes in exchange rates as well. (See appendix for detailed results).

Since the equity return variables are all stationary and not integrated of order 1, I(1), as the exchange rates are, these variables are not cointegrated. Hence, the equity return differentials and the exchange rates do not have a long-term equilibrium relationship. We can therefore go on to test for Granger-causality without including an error correction term.

6.3 MODEL SPECIFICATION

Before we go on to test for Granger-causality we need to specify the models. Firstly, we want to determine whether or not to include the interest rate variable as a control variable. And given that the interest variable should be included in the model, we only want to include those lags that are significant.[9] Secondly, we will apply AIC to settle on the number of lags to include of the explanatory exchange rate and equity return difference variables in the *models 1-6*. The resulting number of lags in each model indicates the lead lag time structure in the relationships. The resulting number of lags in each model is reported in *table 1*.

where k is the number of parameters, n is the number of observations and RSS is the residual sum of squares of the model.

[8] See section 5.2.1 for an explanation.

[9] To decide whether it is appropriate to include the interest variable in the models, we run the regressions of *models 1-6*, with k equal to 1 to 5. We then turn our attention to the t values of the interest variables and their lags. As a decision rule of thumb, we have chosen to proceed with those that have coefficients significant at the 5 % level. We find that for *model 1* the fourth lag of the interest variable has a significant impact, for *model 2* the unlagged variable is significant for all regressions (i.e. irrespective of the k value) and the first lag of the interest variable when $1 < k \leq 5$. For *model 3* the third lag is significant, for *model 4* the second, third and fourth lags, and for *models 5* and *6* no interest variables are significant.

MODEL 1

$$OMXrelEZ_t = \alpha_1 + \sum_{i=1}^{k} \alpha_2 OMXrelEZ_{t-i} + \sum_{i=1}^{k} \alpha_3 SEK/EUR_{t-i} + \sum_{i=0}^{4} \alpha_4 R^{ECB}_{t-i} + u_{1t}$$

MODEL 2

$$OMXrelSP_t = \beta_1 + \sum_{i=1}^{k} \beta_2 OMXrelSP_{t-i} + \sum_{i=1}^{k} \beta_3 SEK/USD_{t-i} + \sum_{i=0}^{4} \beta_4 R^{FED}_{t-i} + u_{2t}$$

MODEL 3

$$OMXrelFTSE_t = \lambda_1 + \sum_{i=1}^{k} \lambda_2 OMXrelFTSE_{t-i} + \sum_{i=1}^{k} \lambda_3 SEK/GBP_{t-i} + \sum_{i=0}^{4} \lambda_4 R^{BoE}_{t-i} + u_{3t}$$

MODEL 4

$$SEK/EUR_t = \phi_1 + \sum_{i=1}^{k} \phi_2 SEK/EUR_{t-i} + \sum_{i=1}^{k} \phi_3 rOMXrelEZ_{t-i} + \sum_{i=0}^{4} \phi_4 R^{ECB}_{t-i} + u_{4t}$$

MODEL 5

$$SEK/USD_t = \gamma_1 + \sum_{i=1}^{k} \gamma_2 SEK/USD_{t-i} + \sum_{i=1}^{k} \gamma_3 OMXrelSP_{t-i} + \sum_{i=0}^{4} \gamma_4 R^{FED}_{t-i} + u_{5t}$$

MODEL 6

$$SEK/GBP_t = \sigma_1 + \sum_{i=1}^{k} \sigma_2 SEK/GBP_{t-i} + \sum_{i=1}^{k} \sigma_3 OMXrelFTSE_{t-i} + \sum_{i=0}^{4} \sigma_4 R^{BoE}_{t-i} + u_{6t}$$

6.4 THE GRANGER CAUSALITY TEST

When the models are specified we can go on to conduct the Granger-causality test. We then again run *models 1-6* above with the appropriate number of lags and with proper inclusion of the interest variable. As described in section 5.2, the test is conducted by running an unrestricted and a restricted regression in order to generate an F-statistic, where the restricted regression, as explanatories, only includes the lagged values of the dependent variable. In the event that the F-statistic is significant, the null hypothesis can be rejected. A rejection of the null hypothesis would imply that we reject that lagged values of equity return differentials, when changes in exchange rates are used as the dependent variable or vice versa, do not Granger cause exchange rates. The results are reported in *table 1*.

TABLE 1. THE RESULTS FROM THE GRANGER-CAUSALITY TEST (THE BASE CASE)

Dependent Variable	Lags	Critical F value (1 % sign.)	Observed F-value	H_0	Result
rOMXrelEZ	1	6.6473	0.000	FX-rate does not cause equity returns	Cannot reject
rOMXrelSP	3	3.7912	0.000	FX-rate does not cause equity returns	Cannot reject
rOMXrelFTSE	2	4.6156	0.000	FX-rate does not cause equity returns	Cannot reject
SEK/EUR	4	3.3284	14.507	Equity returns do not cause FX-rate	Reject
SEK/USD	2	4.6156	8.434	Equity returns do not cause FX-rate	Reject
SEK/GBP	2	4.6156	13.784	Equity returns do not cause FX-rate	Reject

The results are in line with our hypothesis. Relative equity performance uni-directionally Granger causes exchange rates.

6.4.1 FINANCIAL CRISIS CASE

Because of the intense volatility that has characterized the exchange and equity markets for the past six months we thought that it would be interesting to isolate that period and examine if the results would equal the base case in section 6.4. The graphical analyses in section 4 illustrate that both the relative equity performance variables and the exchange rates have reacted dramatically to the financial turmoil. Although, how they have moved in accordance to each other varies between the markets. Further, a large proportion of previous research has studied the causal relationship between exchange rates and equity during the Asian financial crisis and found different results when isolating the crisis period from when they have studied an extended data set.

We have defined the crisis period as; post-the Lehman Brothers collapse (16/9-08) until the end of our data set (27/2-09). We use the same variables as in the base case, with the difference that the exchange rate variables are taken in the first-difference, without conducting any tests on their levels forms. We test for stationarity in the same way as before. As expected, all variables are stationary. We also assess which interest rate differentials that have a significant effect on the dependent variables, by considering their t values and whether these are significant. Despite the central bank's high activeness, with multiple sharp cuts in interest rates, these variables have a low impact on exchange rates and equity returns. The results from the test for Granger-causality are reported in *table 2*.

TABLE 2. RESULTS FROM THE GRANGER-CAUSALITY TEST (THE CRISIS CASE)

Dependent Variable	Lags	Critical F value (1 % sign.)	Observed F-value	H_0	Result
rOMXrelEZ	1	6.8710	0.000	FX-rate does not cause equity returns	Cannot reject
rOMXrelSP	1	3.8732	0.000	FX-rate does not cause equity returns	Cannot reject
rOMXrelFTSE	1	6.8710	0.000	FX-rate does not cause equity returns	Cannot reject
SEK/EUR	1	6.8710	0.000	Equity returns do not cause FX-rate	Cannot reject
SEK/USD	1	6.8710	3.1429	Equity returns do not cause FX-rate	Cannot reject
SEK/GBP	1	6.8710	0.000	Equity returns do not cause FX-rate	Cannot reject

For this period, our hypothesis, that relative equity returns Granger cause exchange rates, must be rejected. At the 5 % significance level, Granger causality does not exist between any pair of variables. At the 10 % significance level, Swedish equity returns relative to the return on US equities granger cause the SEK/USD exchange rate.

7. DISCUSSION

7.1 TECHNICAL DISCUSSION

The results are in line with our hypothesis, relative equity performance uni-directionally Granger causes exchange rates for all currencies in the sample. This is the same result as most previous research on advanced economies have found (see for instance Ajayi et al. (1998), Hatemi-J and Irandoust (2002), and Stavárek (2005)). The choice of using daily observations was motivated by the fact that previous research indicates that this is the appropriate frequency to use in order to capture the causal relation. Although, this study confirms our hypothesis that relative equity returns Granger causes exchange rates on a daily basis, one cannot rule out that one would find Granger-causality if using, for instance, monthly observations as well, as the previous Swedish study did. That would indicate a more long-term causality as oppose to our results that indicate a short-term causality. It could however be the case that capital mobility has gotten faster and equity markets and exchange rates more aligned in the more globalised world economy, as for instance Stavárek (2005) argues. An implication of this evolvement can possibly be that the causal structural dynamics have changed from more long-term to short-term, from monthly to daily. It cannot be discarded that a causal relation could be found in an even higher frequency than daily. There could be a cause and effect relationship between these variables within an intraday.

Another aspect that affects the results of this kind of study is of course the data that one chooses to represent the respective equity markets. We have chosen broad market indices. One may encounter different results if choosing to look at, for instance, only large companies that can be assumed to be involved in relatively more trade. The causal relationship might also depend on which sector a given company is involved in.

An interesting question is whether there is a steady relationship between these variables or if it varies and makes results dependent on which specific time-period one chooses to study. The divergent results from previous studies indicate that this may be the case. We isolated the final six months in our data set, Sept 08 till Feb 09, the crisis period and tested for Granger-causality. The results from these tests were not in line with the results from the base case. During the crises we found no causal relation between relative equity returns and exchange rates in any of the cases. We can therefore conclude that our results to some extent depend on the time-period that we have chosen. The fact that we do not find any Granger-causality during the crisis period can possibly be explained by that, during the market turmoil, equity return differentials and exchange rates have been caused by other omitted or unobserved variables. Pan et al. (2005), Ramasamy and Yeung (2005) and Shew (2008) also found deviating results when they separately studied the Asian financial crisis which was included in their longer term data sets on Asian countries.

The test for Granger-causality provides information about whether past values of one variable carries information useful to predict another variable. The test in itself does not generate an answer to how a variable, that Granger causes another variable, is causing the other variable. For instance, if Granger-causality is uni-directional from X to Y, the test does not reveal whether X has a positive or negative impact on Y. However, you can still look at the coefficients from the estimated regressions involving the lags of, say, X – and they do have a sign which you can infer some conclusions from.

We have found Granger-causality running from relative equity returns to exchange rates. The results are in accordance with the Stock theory in that the equity market causes exchange rates. The Stock theory suggests that when domestic equities perform relatively better than a foreign country's equities, the domestic currency appreciates against the foreign country's currency. In this case, that implies that the relative equity performance variable should have a negative impact on the exchange rate variable. To evaluate whether that is the case we turn to the sign of the coefficients in the models. All coefficients and their t values are reported in the appendix. From there one can see that when considering the unrestricted regressions, having exchange rate variables as dependents, all lagged equity return variables have positive coefficients. Of those, many (at the 5 % significance level, at least one for each regression) are significant. From this, we draw the conclusion that there is a positive relation between relative Swedish

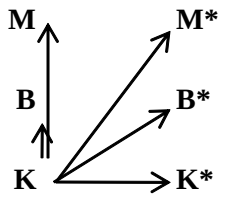
equity returns and the Swedish exchange rate, i.e. the opposite of what the Stock theory would suggest. We also note that it is mainly the first two lags of equity return variables that explain movements in the exchange rates (implying that it takes up to two days for equity returns to alter the exchange rate). That is, relatively better performing Swedish equities generate a depreciation of the Swedish krona, and vice versa.

Another interesting observation is that in the British case, the second lag has a much stronger explanatory power than the first. This implies that the effect of a rise in Swedish equity prices, relative to British, on the exchange rate not only persists over two days, but it mainly takes place in the second day.

7.2 INTERPRETATION OF RESULTS

The fact that we have found Granger causality running from relative equity returns to the exchange rates with a positive sign raises the question how this can be explained theoretically. As mentioned in section 2.2, the Stock theory proposes a negative relation between these two variables. One reason is said to be that the rise in wealth that comes from an exogenous increase in domestic equity prices, increase the demand for domestic money, according to Stavárek (2005), Granger et al. (2000) and others. Here we want to argue, though, that if we allow for more asset types, the effect could be the opposite. Let us assume that investors allocate their wealth among domestic and foreign money (M and M*), domestic and foreign bonds (B and B*) and domestic and foreign equities (K and K*). It then seems reasonable to assume that only a fraction of the increased wealth will be held as domestic money, the rest will be invested in B, B*, M* and K*. Depending on how the newly gained wealth is allocated among these assets, the exchange rate may change in any direction. For instance, an increased demand for B has a negative effect on the domestic interest rate. For the domestic interest rate to increase, the increase in demand for M must dominate the increase in demand for B. We could also imagine a situation where the increases in M and B exactly outweigh each other, leaving an increased demand for foreign assets, with a negative effect on the domestic currency's value, as the only net effect. The effects can be illustrated as in *figure 4*, where the arrows represent wealth being transferred from K to the other asset types when K increases exogenously.

FIGURE 4



We can now apply this extension of the Stock theory on the Swedish market. When Swedish equity prices rise relative to foreign equities, they will make up a larger fraction of investors' portfolios. To diversify the risk, investors will then tend to buy more Swedish bonds and foreign assets. The increased demand for Swedish bonds pushes down the Swedish interest rate and leads to a depreciation of the Swedish krona. At the same time, the increased demand for foreign assets has a positive effect on the value of the foreign currency, relative to the Swedish krona. Our test results indicate that for Sweden, these effects dominate the increase in demand for domestic money, resulting in a net effect which leads to a depreciation of the Swedish krona when Swedish equities perform well, i.e. K increases. A strong point of this explanation is that it, in contrast to one based on consumption changes caused by changes in wealth (and resulting in a higher demand for transactions), relies on effects which we regard as viable even for the short-term frequency that we have used in the tests. We believe that an increase in equity prices does not, on a day-to-day basis, encourage individuals to increase their consumption.

Another effect is, as described in section 2.2.2, that in order to purchase domestic equities, investors need to acquire domestic money. But we consider this effect as being questionable. It is clear that investors do need domestic money in order to acquire domestic equities, but once they have carried out the purchase, the sellers of the equities possess this money. Thus, the demand for domestic money, and hence the exchange rate, depends on how these investors choose to allocate the money.

7.2.1 OMITTED VARIABLES

Granger (1980) emphasizes that the occurrence of missing variables can lead to misinterpretation of one's result. For instance, exchange rates and equity returns could be caused by fundamental shocks other than shocks from exchange rates and equity prices, respectively. The results might then be spurious, that is, it just appears to be a causal relationship since one or more explanatory variables are omitted.

To avoid such problems, we have, similar to Granger et al. (2000), controlled for exogenous interest rate changes. By doing so, we hope to isolate the causality between exchange rates and equity returns, and to avoid or at least mitigate any spurious results.

7.2.1.1 DOMESTIC OUTPUT

However, other omitted variables may still exist. For example, it could be relevant to include domestic output as an explanatory variable in the model. We cannot be sure of whether the positive relation between equity returns and the exchange rate actually is best explained by a positive impact by equity returns on the exchange rate, like the Stock theory suggests, or if it is exogenous changes in domestic output that alter both exchange rates and equity returns. If we control for domestic output, and the result from the Granger causality test still generates the same result, one gets further support for the hypothesis; that equity returns Granger cause the exchange rate, for instance due to the mechanisms suggested by the portfolio-balance approach. If the Granger test, on the other hand, proposes no causality when domestic output is controlled for, one can conclude that the relation between equity returns and the exchange rate is not causal but explained by domestic output. In practice, a problem of including domestic output when dealing with daily observations could be that GDP is generally not measured on a daily basis. Thus, possible movements in GDP occurring between the measurements events would be undetected.

7.2.1.2 INFLATION

Another issue that could be of interest is inflation. Since we have used nominal values in our tests, differing inflation rates in the markets which we deal with can have affected both equity returns and exchange rates. For instance, a higher rate of inflation in Sweden than in the U.S. can be assumed to have caused Swedish nominal equity prices to rise relative to equity prices in the U.S., while the Swedish krona assumingly would have depreciated over time. Hence, a positive relation between equity returns and the exchange rate could have appeared merely due to inflation differences.

The inflation might also affect the interest variable. Fazel (2005) argues that the effect of an interest rate change may deviate depending on whether the change constitutes an adjustment of the real interest rate or if it is motivated by a change in inflation. The cause of nominal interest rate changes is, hence, varying and that can possibly explain why the character of the causal relationship between exchange rates and equity returns is not steady.

The problem can be circumvented either by controlling for inflation rates, or by using real variables. But the same problem as for GDP could apply when one uses daily observations. Namely, price levels are normally not measured on a daily basis. However, the inflation rates in Sweden, the Euro Zone, the U.S. and Great Britain have been relatively stable and, more importantly, have been on relatively similar

levels, over the time period that we have considered. Therefore, we do not believe that the fact that we have not controlled for inflation has any considerable effect on our results.

7.2.1.3 EXPECTATIONS

Finally, an issue related to the one of inflation, is expectations. It could be the case that causality stems from changes in expectations, rather than from the current changes in the variables. Especially, this could be an explanation for the positive relation between the Swedish relative (central bank) interest rate and Swedish equity returns, observed in some of the models (see appendix). Normally, a relative increase in the repo rate can be assumed to lead to a relative fall in domestic equity prices. But if the central bank's increase of the interest rate is seen as a sign of brighter future prospects, the effect may be the opposite. Likewise, an increased interest rate (i.e. reduced money supply) could cause a depreciation of the domestic currency if, say, the policy action is accompanied by statements declaring that the inflation is expected to become more threatening than the market expected. This could alter the expected future exchange rate, E^e. A way of handling this problem is to incorporate futures and forwards prices in the model.

8. CONCLUSION

We are not able to reject our hypothesis, that relative equity returns uni-directionally Granger causes exchange rates for SEK/USD, SEK/EUR and SEK/GBP. Although we have studied relative equity returns as oppose to a single markets performance as most previous research has done, the results are in line with previous findings. However, the fact that we do not find any Granger-causality when we study only the final six months in our data set (the crisis period), implies that the results are dependent on the time-period of study. In advanced economies empirical studies tend to show that equity prices Granger causes exchange rates. To our surprise though, the relationship is positive, a relatively stronger Swedish market causes the Swedish krona to depreciate. This is in contrast to what our theoretical base suggested, but can be explained if we extend the theory to take on a broader perspective, allowing for other types of assets.

Traditionally, the Stock theory assumes increasing domestic equity prices to cause an appreciation of the domestic currency. This is explained by two mechanisms. First, higher wealth leads to increased money demand, pushing up the interest rate and hence the value of the currency. Second, and with the same effect on the interest rate and the exchange rate, investors have to acquire domestic money before they can buy domestic equities. We explain the divergence from the expected results by taking investors' willingness to diversify their portfolios into consideration. When the value of their domestic equities rises, they will be prompted to increase their demand for interest bearing bonds and foreign assets, which

alters the equilibrium price of foreign exchange. Additionally, it could prove to be beneficial to include inflation in the model to control for its effect on exchange rates and equity returns. Another question is if the flow theory, assuming a depreciated currency to boost domestic equity prices, would have a dominant effect if a more long-term perspective were to be considered. Such a study could be the subject of further research.

Aggarwal, R. (1981) "Exchange Rates and Stock Prices: A Study of the US Capital Markets Under Floating Exchange Rates", Akron Business Economic Review, Vol 12, pp. 7-12.

Ajayi R.A., Friedman J., Mehdian S.M. (1998) "On the Relationship between Stock Returns and Exchange Rates: Tests of Granger Causality", Global Finance Journal, Vol. 9, pp. 241-51.

Bahmani-Oskooee Mohsen and Ahmad Sohrabian (1992), "Stock Prices and the Effective Exchange Rate of the Dollar," Applied Economics, Vol. 24, pp. 459-464.

Bodie, Z., Kane, A., Marcus, A.J. (2007), *Investments*. 7th ed., Boston: McGraw-Hill.

Dickey, D. A. and W. A. Fuller, (1979), "Distribution of the Estimators for Autoregressive Time Series With a Unit Root," Journal of the American Statistical Assoc., Vol. 74(366), pp. 427-431.

Dong, Shuh-Chyi, Yang, Sheng-Yung, Wang, Alan T. (2005) "The Dynamic Relationship and Pricing of Stocks and Exchange Rates: Empirical Evidence from Asian Emerging Markets", Journal of American Academy of Business, Vol. 7, No. 1, pp. 118-123.

Elliot, G., Rothenberg, T.J. and J.H. Stock, (1996), "Efficient tests for an autoregressive unit root," Econometrica, Vol. 64(4), pp. 811-636.

Engle, Robert F. and C.W.J. Granger (1987), "Cointegration and Error Correction: Representation, Estimation and Testing," Econometrica, Vol. 55, pp. 251-276.

Fazel, S. (2004) "The Euro and Equity Markets in Euro-Zone Countries". Journal of Economics and Economic Education Research, Vol. 5, Number 3, pp. 111-118.

Franck, P. and Young, A. (1972) "Stock Price Reaction of Multinational Firms to Exchange Rate Realignments", Financial Management, Vol 1, pp. 66-73.

Granger, C.W. J. (1969). "Investigating causal relations by econometric models and cross-spectral methods" Econometrica, Vol. 37(3), pp. 424–438.

Granger, C. W. J. (1980), "Testing for Causality: A Personal Viewpoint," Journal of Economic Dynamics and Control, Vol. 2, pp. 329-352.

Granger, C. W. J. (1988). "Some recent developments in a concept of causality." Journal of Econometrics, Vol. 39, pp. 199–212.

Granger, C.W.J, Huang, B-N. and Yang, C-W. (2000) 'A bivariate causality between stock prices and exchange rates: evidence from recent Asian flu. The Quarterly Journal of Economics and Finance, Vol. 40, pp. 337-354.

Gujarati, D. (2003), *Basic Econometrics*. 4th ed., Boston: McGraw-Hill.

Hatemi-J, A. and Irandoust, M. (2002). 'On the Causality between Exchanges Rates and Stock Prices: a note', Bulletin of Economic Research, vol. 54(2), pp. 197-203.

Hoover, K.D. (2001), Causality in Macroeconomics. , Cambridge University Press.

Krueger, A. O. (1983), *Exchange-Rate Determination*. Cambridge: Cambridge University Press.

Krugman, P. R., & Obstfeld, M. (1997), *International Economics: Theory and Policy*. 4th ed., Reading: Addison-Wesley Inc.

Pan, Ming-Shiun, Fok, Robert Chi-Wing and Liu, Y. Angela, 2007. "Dynamic linkages between exchange rates and stock prices: Evidence from East Asian markets", International Review of Economics and Finance, Vol. 16, pp. 503-520.

Rosenberg, M., (2003), Exchange-rate determination: models and strategies for exchange-rate forecasting. New York: McGrw-Hill.

Sorensen, B.E., (2005), Granger Causality.

Stavárek, D. (2005). "Stock Prices and Exchange Rates in the EU and the USA: Evidence of Their Mutual Interactions." Finance a Uver/Czech Journal of Economics and Finance, Vol 55 (3-4), pp. 141-61.

Toda, H. and Yamamoto T. (1995), "Statistical inference in vector autoregressions with possibly integrated processes", Journal of Econometrics, Vol. 66, pp. 225-250.

Wooldridge, J. M. (2009), *Introductory Econometrics*. 4th ed., Mason, Ohio: South-Western Cengage Learning.

2001-2009

Outcome from the ADF tests:

Variable	Lags	t
lnSEK/EUR	0	0.487
lnSEK/USD	0	-1.196
lnSEK/GBP	0	-2.035
ΔlnSEK/EUR	0	-47.864
ΔlnSEK/USD	1	-34.405
ΔlnSEK/GBP	0	-43.468
rOMXrelEZ	2	-28.734
rOMXrelSP	2	-32.657
rOMXrelFTSE	0	-48.646
Δ(SweR-EurR)	0	-46.934
Δ(SweR-UsR)	0	-45.667
Δ(SweR-GrbR)	0	-45.901

Granger causality test, the UR regressions:

Dependent: ΔlnSEK/EUR

Explanatory	Beta	t
ΔlnSEK/EUR(t-1)	-0.075	-3.374
ΔlnSEK/EUR(t-2)	-0.089	-4.02
ΔlnSEK/EUR(t-3)	-0.023	-1.053
ΔlnSEK/EUR(t-4)	0.011	0.519
rOMXrelEZ(t-1)	0.03	1.345
rOMXrelEZ(t-2)	0.044	1.967
rOMXrelEZ(t-3)	0.025	1.091
rOMXrelEZ(t-4)	0.026	1.146
Δ(SweR-EurR)(t-2)	-0.065	-2.96
Δ(SweR-EurR)(t-3)	-0.058	-2.628
Δ(SweR-EurR)(t-4)	-0.062	-2.829

Note: Beta refers to standardised coefficients. That is, the mean predicted value is subtracted from the predicted value, and the difference is divided by the standard deviation of the predicted values. Standardised predicted values have a mean of 0 and a standard deviation of 1.

Dependent: rOMXrelEZ

Explanatory	Beta	t
ΔlnSEK/EUR(t-1)	0.002	0.101
rOMXrelEZ(t-1)	-0.144	-6.58
Δ(SweR-EurR)(t-4)	0.051	2.329

Note: Beta refers to standardised coefficients.

Dependent: ΔlnSEK/USD

Explanatory	Beta	t
ΔlnSEK/USD(t-1)	-0.027	-1.215
ΔlnSEK/USD(t-2)	-0.068	3.194
rOMXrelSP(t-1)	0.075	-3.093
rOMXrelSP(t-2)	0.065	2.765

Note: Beta refers to standardised coefficients.

Dependent: rOMXrelSP

Explanatory	Beta	t
ΔlnSEK/USD(t-1)	-0.029	-1.376
ΔlnSEK/USD(t-2)	-0.021	-1.005
ΔlnSEK/USD(t-3)	-0.023	-1.119
rOMXrelSP(t-1)	-0.387	-17.424
rOMXrelSP(t-2)	-0.157	-6.667
rOMXrelSP(t-3)	-0.047	-2.122
Δ(SweR-UsR)	-0.095	-4.592
Δ(SweR-UsR)(t-1)	-0.041	-1.96

Note: Beta refers to standardised coefficients.

Dependent: ΔlnSEK/GBP

Explanatory	Beta	t
ΔlnSEK/GBP(t-1)	0.039	1.774
ΔlnSEK/GBP(t-2)	-0.065	-2.995
rOMXrelFTSE(t-1)	0.01	0.464
rOMXrelFTSE(t-2)	0.051	2.302

Note: Beta refers to standardised coefficients.

Dependent: rOMXrelFTSE

Explanatory	Beta	t
ΔlnSEK/GBP(t-1)	-0.026	-1.163
ΔlnSEK/GBP(t-2)	0.009	0.396
rOMXrelFTSE(t-1)	-0.068	-3.074
rOMXrelFTSE(t-2)	-0.031	-1.406
Δ(SweR-GbrR)(t-3)	0.07	3.175

Note: Beta refers to standardised coefficients.

The outcome from the ADF tests:

Variable	Lags	t
ΔlnSEK/EUR	0	-11.916
ΔlnSEK/USD	0	-11.475
ΔlnSEK/GBP	0	-9.881
rOMXrelEZ	0	-13.171
rOMXrelSP	0	-15.977
rOMXrelFTSE	0	-11.749
Δ(SweR-EurR)	0	-10.566
Δ(SweR-UsR)	0	-10.562
Δ(SweR-GrbR)	0	-10.489

Granger causality test, the UR regressions:

Dependent: ΔlnSEK/EUR

Explanatory	Beta	t
ΔlnSEK/EUR(t-1)	-0.133	-1.403
rOMXrelEZ(t-1)	0.063	0.669

Note: Beta refers to standardised coefficients.

Dependent: ΔlnSEK/GBP

Explanatory	Beta	t
ΔlnSEK/GBP(t-1)	0.055	0.583
rOMXrelFTSE(t-1)	0.112	1.175

Note: Beta refers to standardised coefficients.

Dependent: rOMXrelEZ

Explanatory	Beta	t
ΔlnSEK/EUR(t-1)	-0.002	-0.025
rOMXrelEZ(t-1)	-0.229	-2.45

Note: Beta refers to standardised coefficients.

Dependent: rOMXrelFTSE

Explanatory	Beta	t
ΔlnSEK/GBP(t-1)	-0.045	-0.472
rOMXrelFTSE(t-1)	-0.112	-1.172

Note: Beta refers to standardised coefficients.

Dependent: ΔlnSEK/USD

Explanatory	Beta	t
ΔlnSEK/USD(t-1)	-0.113	-1.162
rOMXrelSP(t-1)	0.098	1.007

Note: Beta refers to standardised coefficients.

Dependent: rOMXrelSP

Explanatory	Beta	t
ΔlnSEK/USD(t-1)	-0.088	-0.999
rOMXrelSP(t-1)	-0.412	-4.645
Δ(SweR-UsR)	-0.182	-2.086

Note: Beta refers to standardised coefficients.