The Relationship between Stock Prices and Exchange Rates in Sweden

Bachelor Thesis in Economics
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Abstract

This paper empirically investigates the exchange rate effects of Swedish krona against euro (SEK/Euro) on stock prices in Sweden. The sample period for the study has been taken from March, 2001 to March, 2011 using monthly nominal exchange rate of SEK/Euro and monthly closing values of OMX Stockholm All Share (OMXPI) Index. The developed unit root test and cointegration technique have been applied for the research. It was found that both data series were nonstationary and integrated of order 1. The test result also showed there was no cointegrating relationship between stock prices and exchange rates. Further investigation into their contemporaneous relationship highlighted a statistically significant negative linear relationship between the said variables, suggesting that an appreciation of the Swedish krona against euro leads to a contemporaneous increase in the value of the Swedish stock market.
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1 Introduction

The interactions between stock markets and foreign exchange markets have received considerable attention of researchers and practitioners in both developed and developing countries. The concern on their mutual relations emanated with the significant changes in the international financial system in the last quarter of the century. These changes were mainly reflected in the emergence of new capital markets, the adoption of more flexible exchange rate policies and the relaxation of foreign capital controls. All these new features have contributed to a broader selection of worldwide investment opportunities as well as the portfolio diversification strategies. However, the accompanying increases in the exchange rates volatility added a substantial portion of risk to the multinational corporations as a result of international trade activities (Stavárek, 2004). The continuing increases in the volume of world trade flows and capital movements have made the exchange rates as one of the main determinants of business profitability and hence the equity prices (Kim, 2003).

Dimitrova (2005) points out several reasons of the importance to establish the relationship between stock prices and exchange rates from the points of view of policy makers, multinational companies, investment communities and economists.

First, it may affect decisions about monetary and fiscal policy. Suppose the causation runs from exchange rates to stock prices, and then the policy-makers may fortify the economy’s stock market by enhancing its exchange rate market conditions, for instance, reducing excessive fluctuations of exchange rates or regulating favourable exchange rate policy. At times policy-makers prefer less expensive currency policy for the sake of boosting the country’s export sectors. In such case it is necessary to be aware that whether the local currency depreciation would depress the stock market.

Second, the association between the two markets may be used to predict the path of the exchange rate. In the globally intertwined economy, in which there are little or few barriers to the flow of capital, understanding the dynamic links between stock and foreign exchange markets will benefit multinational corporations in managing their foreign exchange rate exposure and stabilizing their earnings.

Third, currency is quite often being included as an asset in investment funds’ portfolios. Knowledge about the link between currency rates and other assets in a portfolio is vital for the performance of the fund. Understanding the relationship between exchange rates and stock prices may also enable the manager to manage risk efficiently. If the two markets are related then investors can use this matter of fact to predict the behaviour of one market using the information on the other market. Such information can be used to hedge their return on foreign investment and for speculation by investors. Furthermore, developing countries can exploit such a link to attract and stimulate foreign portfolio investment in their own countries.

Last, the understanding of the relationship between stock price and exchange rate may prove helpful to foresee a crisis. The issue of whether stock prices and exchange rates are related or not has received considerable attention after the late 1990s East Asian crises. During the crises the world has noticed that the emerging markets collapsed due to substantial depreciation of exchange rates and dramatic fall in the stock prices. Ito and Yuko (2004) argue that the link between the stock and foreign exchange markets facilitated propagating the Asian Financial Crisis in 1997. It is widely believed that the sharp depreciation of the Thai baht ignited the collapse of the stock market. If stock prices and exchange rates are related and the causation runs from exchange rates to stock prices then awareness about such relationship might trigger preventative actions.
The present study is aimed to analyze price interactions between two main components of the financial market, stock market and foreign exchange market in Sweden. It considers simultaneously both the long-run and short-run dynamics of the financial market. To the author’s best knowledge, in the context of Swedish economy, however, study in the field of the contemporaneous impact of foreign exchange rate movements on stock prices is not available, though the issue of their causal relationship is gaining importance in recent years and has been investigated extensively in both developed and developing countries. This paper tends to undertake such task to fill the gap in this field.

1.1 Purpose

The objective of this paper is directed towards the detection of significant interactions between the stock prices and exchange rates. The main motivation of this paper is to answer the research question:

Is there a significant contemporaneous effect of exchange rate changes on stock prices in Sweden?

1.2 Method

In order to investigate the contemporaneous relationship between the two major financial assets, exchange rates and stock prices, of Sweden, an empirical analysis is conducted by employing the cointegration technique. Provided that these two variables are cointegrated, the Error Correction Model (ECM) could be further applied to study their relationship in short-run term. Before carrying out these methods, unit root tests are performed to check the stationarity of data series.

1.3 Outline

The rest of paper is structured in the following ways. Section 2 mainly reviews literatures related to the hypothesis and modelling approach of this paper both theoretically and empirically. The third section focuses on clarifying some classic economic theories which illustrate the dynamic interactions between stock market and foreign exchange market. Empirical methodology and data part introduce the unit root test, cointegration technique as well as the error correction model, and a description of data used in this research is also presented. In section five, the empirical test results are to be reported accompanied with a detailed analysis. The last section is dedicated to the conclusion regarding answering the research question, with some additional remarks and suggestions concerning the further investigation within this topic.
2 Literature review

The theoretical and empirical relationship between stock prices and exchange rates has been debated for many years. Observed from the extant literature, the relationship between exchange rate and stock price has not yet gained common conclusion either theoretically or empirically.

There have been several different theoretical models which have built linkages between stock prices and exchange rates, such as the “IS-LM-BP” model developed by Dimitrova (2005), the “flow-oriented” models (traditional approach) by Dornbusch and Fisher (1980), the portfolio balance models by Branson (1983) and the monetary models by Gavin (1989). However, the first two promote a positive relation between these two financial variables while portfolio balance models argue that stock price movements have a negative impact on the changes in the exchange rate. The monetary models suggest no evident association could be recognized unless both exchange rates and stock prices are affected by the same factors. The next section will illuminate the theoretical issues regarding the interactions between stock market and foreign exchange market in more detail.

The empirical analyses using a variety of approaches for the investigation of the relationships between stock prices and exchange rates can also be found in numerous literature, but the results are somewhat mixed as to the significance and the direction of influences between these two variables for a variety of countries. This section focuses on the research findings of their contemporaneous relationship from previous literature that are especially relevant to this study. The results vary from country to country, depending on the type of data used or local exchange rate regimes adopted.

Solnik (1987) employed regression analysis on monthly and quarterly data from 1973 to 1983 for eight countries: Canada, France, Germany, Japan, Netherlands, Switzerland, U.K., and U.S., which represent over ninety percent of the world market capitalization. He used stock return differential as the exogenous variable and found a statistically significant positive effect of real domestic stock returns on real exchange rate movements in all the countries.

Ajayi et al (1998) took daily closing stock market indices and foreign exchange rates to investigate relations between stock returns and changes in exchange rates for eight Asian emerging markets from 1987 to 1991 and G-7 (Canada, Germany, France, Italy, Japan, U.K. and U.S.) countries from 1985-1991. They reported that significant contemporaneous adjustments are found in three of those eight emerging markets, and advanced economies exhibit significant contemporaneous effects running from stock markets to currency markets.

However, Nieh and Lee (2001) did not find any long-run significant relationships between stock prices and exchange rates in the G-7 countries. Their analysis also adopted daily data for each G-7 countries but covered the sample period from 1993 to 1996. The methodology consisted of both the Engle-Granger (EG) two-step procedure and the Johansen maximum likelihood cointegration test. Vector error correction model (VECM) is further applied to assess the short-term intertemporal comovement between the two variables and only one day’s short-run significant relationship has been found in Germany, Canada, U.K., Italy and Japan. The U.S. does not show any significant correlation either in the short-run or long-run. These research results might be explained by differences in economic stage, government policy and expectation pattern.

Yau and Nieh (2006) employed various time series methodologies to examine both long-term and short-term relationships among the stock prices of Japan and Taiwan and the
NTD (New Taiwan Dollar/Yen exchange rate). This research covered the sample period of 1991 to 2005. Their findings reveal that, for the relationship between each of the stock price and exchange rate, the portfolio approach is supported for the short-term in the Taiwanese financial market, whereas the traditional approach is plausible for the long-term in the Taiwanese financial market. The portfolio approach is not suitable to Japan’s market as Japan is found to be more like an import-led country. In addition, there appears to be no long-run equilibrium relationship among NTD/Yen exchange rate and the stock prices of Taiwan and Japan.

Kim (2003) studied the long-run equilibrium relationship between the aggregate stock price and real exchange rate in the U.S. by applying Johansen’s cointegration methodology to monthly data for the 1974-1998 period. This study found that the S&P 500 index is negatively related to the real exchange rate, whereas the research conducted by Ozair (2006) using quarterly data from 1960 to 2004 showed no cointegration between these two variables in U.S.

Doong, et al (2005) examined the dynamic linkage between stock prices and exchange rates for six Asian emerging financial markets, and found no cointegration relationship existed between these two variables. But the stock returns exhibit a significant negative relation with the contemporaneous change in the exchange rates for all countries except Thailand, implying that the currency depreciation accompanies with a drop in the stock prices. Besides, when using data from 2001 to 2008 for Turkey, Aydemir and Demirhan (2009) found a negative relationship from exchange rate to all stock market indices as well.

2.1 Exchange rate exposure

Studies have also examined firms’ exchange rate “exposure”. Adler and Dumas (1984) firstly analyze exchange rate risks in a way that conforms to the interests of stockholders and analysts. In his article, exchange rate exposure of a firm refers to the degree to which the value of a firm is affected by changes in exchange rate. This concept of exchange rate exposure is widely accepted by other scholars as it connects foreign exchange rate exposure with stock return or cash flow of a firm, making the measure of foreign exchange rate exposure quantitatively.

Jorion (1990) opened the road for academic research in this field by examining the exposure of U.S. multinational corporations to foreign currency risk. This study focused on the determinants of exchange rate exposure and concluded that the relationship between stock returns and exchange rates differs systematically across multinationals, but the two financial variables are positively related to the proportion of foreign operations of U.S. multinationals. Bartov and Bodnor (1994) re-examined the relation between contemporaneous as well as lagged changes in the U.S. dollar and firm value for a sample of selected firms that are likely to have similar exchange-rate exposures. They concluded that contemporaneous changes in the dollar value have little power in explaining abnormal stock returns, but lagged changes in the dollar are found to be significantly negatively associated with the abnormal stock returns of their sample firms, which suggests that mispricing is occurring. Research conducted outside the U.S. also addresses the corporate exposure of companies in some developed countries. For instance, Glaum et al. (2000) investigated the economic exposure of German corporations to changes in the nominal exchange rate of the German mark against the US dollar during 1974-1997 and found that German firms are significantly exposed to the changes in the DM/USD rate. A sample of Dutch companies have been researched by De Jong et al. (2002) that found more than 50% of the firms are significantly exposed to exchange rate risk. Furthermore, they identified that the firm size and the for-
eign sales ratio are statistically significantly and positively related to exchange-rate exposure. Doukas et al. (2003) examined the relationship between Japanese stock returns on a number of 1079 companies’ shares traded on the Tokyo Stock Exchange and the unanticipated Japanese yen exchange-rate changes over the period of 1975 - 1995. Their results indicated a statistically significant relation between contemporaneous stock returns and exchange rate movements, and the estimated exposures are higher in the case of multinational and exporting companies in comparison to low-exporting and domestic firms. Their research also revealed that the comovement between these two variables is found to be positively related to the degree of the firm’s foreign economic involvement and inversely associated with its size and debt to asset ratio.

Based on the above discussion it is clear that the theoretical economics as well as empirical researches are far from any consensus related to the interactions between stock market and foreign exchange market. This research is expected to contribute to the existing literature in adding to existing empirical evidence in this area.
3 Theoretical framework

The existing literature sets the theoretical groundwork of the linkages between stock prices and exchange rates mainly on two perspectives, typically referred to as the macroeconomic and the microeconomic level (Alexandra and Livia, 2007). This section is dedicated to clarify some classical economic theories related to the theoretical issues of the relationship between the stock market performance and the exchange rate behaviour, especially with a focus on how stock price is affected by exchange rate changes, from these two points of view.

The theoretical justification on whether there is a significant relationship between stock prices and exchange rates from the macroeconomic standpoint has been attempted via two essential treatments to exchange rate determination, current account factor and capital account factor. Two subsets of this category, traditional approach and asset market approach are to be introduced in detail as follows. The microeconomic viewpoint underlines the issue of firms' exposure to exchange rate risk. As this study mainly deals with the stock market performance as a whole, the market economic exposure to exchange rate risk is to be discussed in particular.

3.1 Traditional approach

Traditional approach (Dornbush and Fisher, 1980) emphasizes the current account and trade balance performance as the key determinants of exchange rate. The linkage between stock prices and exchange rates at the macro level might be sensitive to the exchange rate regime in force (Alexandra and Livia, 2007). A group of economists believed that the currency appreciation under a floating exchange rate regime would reduce the international competitiveness of local product and affect the trade balance position of the nation. Eventually, the firms' future cash flows are affected due to the real output deterioration and this will result in lower stock prices. The transmission mechanism according to this approach is the price competitiveness of the firm's exports. Less attractive exporting goods will lead to a decrease in foreign demand, resulting in changes in the value of the firm's assets and liabilities denominated in foreign currency, culminating in lower corporate revenue and hence ultimately reflecting its stock prices (Kutty, 2010). Generally, traditional approach advocates a positive correlation between the exchange rate and stock price.

An appreciation of the local currency decreases profits for an exporting firm because it leads to a fall in foreign demand of its products. On the other hand, the sensitivity of the value of an importing firm to exchange rate fluctuations is the opposite to that of an exporting firm (Nath and Samanta, 2003). Therefore, the relationship would be negative if many firms use lots of imported raw materials in their production. In such scenario, decrease in their costs of production due to currency appreciation is likely to boost firms'
sales and profits that might lead to an increase in their stock prices (Muhammad and Rasheed, 2002). Conversely, in short, for a country relying on imports, an appreciation of the domestic currency lowers input cost and may generate a positive impact on the stock market. That is, whether currency appreciation has a negative or positive impact on local stock market to a large extent rests with whether this country is export-dominant or import-dominant (Aydemir and Demirhan, 2009). Seen in this way, when a firm is engaged in both external trading activities, it might be difficult to identify an obvious impact of exchange rate changes on stock prices. On one hand the firms benefit from domestic currency depreciation due to the increase in prices of their exporting goods, while on the other hand these firms suffer from the rising cost of production due to the increase in the prices of their imported inputs. Under such circumstance, the stock price may not rise at all as the increasing cost of production will cancel out the beneficial effect obtained from the exporting goods (Muhammad and Rasheed, 2002).

It is generally acknowledged that the traditional approach supports the idea that the exchange rate positively influences the stock prices. While according to the discussion above, the analytical perspective behind this approach could lead to mixed results in reality, depending on the characteristics of the firms, industries or the whole market. Like what Nath and Samanta (2003, p.2) concluded in their paper, ‘on a macro basis, the impact of exchange rate fluctuations on stock market seems to depend on both the importance of a country’s international trades in its economy and the degree of the trade imbalance.’

As a note of caution, the fluctuations in domestic stock market could also generate a significant impact on the foreign exchange market. The portfolio balance approach developed by Branson (1983) postulates that stock price movements lead to changes in exchange rates with negative correlation. In this way, there is a likelihood that changes in one market condition which lead to changes in the other will have feedback (bilateral causality) effect if the traditional approach and portfolio balance approach work simultaneously (Hussain and Liew, 2004). However, this paper intends to study the contemporaneous effect of exchange rate changes on stock prices. The issue of the causality relationship between them is beyond the research of this paper.

### 3.2 Asset market approach

According to the asset market approach, currencies are viewed as nothing more than a type of financial asset that is traded in the international asset market. Thus an exchange rate is the price of an asset (price of one unit of currency) that is no longer only driven by economic variables relevant to the trade or capital flows in the balance of payments, but determined by the conditions of international asset market equilibrium. Factors such as future interest differentials between the countries, terms of trade, economic and political conditions that cause changes in people’s expectation on future values of exchange rate will reflect in today’s spot exchange rate. So, there should not be any associations between stock price and exchange rate if the factors that cause movements in both assets are different. However, if stock prices and exchange rates are affected by some common factors such as the interest rate, one might expect a linkage between these two financial variables (Mu-

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3 Portfolio balance approach presumes internationally diversified portfolios and exchange rate plays a role of balancing the demand and supply of domestic and foreign assets. An increase in domestic stock prices leads to a rise in the demand of domestic assets and a drop in the demand of foreign assets, causing local currency appreciation. The rising money demand due to local currency appreciation will push up domestic interest rate, leading to a further appreciation of domestic currency by attracting foreign capital. For more about portfolio balance approach see Muhammad and Rasheed (2002) or Hussain and Liew (2004).
hammad and Rasheed, 2002). The monetary model developed by Gavin (1989) generally delivers the same idea, so this approach is also known as monetary approach (Stavárek, 2004). Some textbooks classify portfolio balance approach and monetary approach into the asset market approach category since both approaches stand for the point that exchange rate is determined by the market equilibrium.

Consequently, the outcome of the argument from the above mentioned approaches basically suggests that no theoretical consensus has been reached concerning the interactions between foreign exchange markets and stock markets.

3.3 Currency-risk exposure

Currency risk, or exchange rate risk, is a form of risk that arises from the unexpected change in price of one currency against another. This kind of financial risk occurs when companies are involved in an international business operating environment with their assets or liabilities across national borders or denominated in foreign currencies.

Dopsy and Nazarian-Ibrahimi (1994) pointed out that exchange rate exposure of a country’s stock market measures the sensitivity of the market stock price index to unforeseen changes in the exchange rate. The exchange rate risk can therefore be measured by estimating the corresponding exposure coefficient.

They also argued that exchange rates influence international stock markets for two reasons. First, the exchange rate regimes have moved towards more flexibility, from pegged arrangements to semi-fixed and even free floating regimes. Taking Sweden as an example, the Swedish krona (SEK) was unilaterally semi-fixed to a basket of currencies from the beginning of the 1980s, and unilaterally semi-fixed to the European Currency Unit (another basket of currencies) from May 17, 1991. On November 19, 1992, Swedish krona (SEK) was devaluated, and since then it has been floating freely against all currencies (Dahlquist and Robertsson, 2001). The adoption of more flexible exchange rate arrangements increases the volatility of exchange rate. Foreign exchange rate volatility can have a significant effect on the stock market since the terms of competition, the input and output prices, and the value of firms’ assets and liabilities denominated in foreign currencies are all subject to adjustments to the fluctuations in the foreign exchange rates (Tabak, 2006). Pure free floating exchange rates are rare: when flexible rates became more volatile and less predictable than expected, most central banks begin to intervene in foreign exchange markets through changes in interest rates or other means of controls. Thus, exchange rate risk has become a significant source of uncertainty on the stock market. Second, study the effects of exchange rate changes on the stock returns is needed because most exchange rate fluctuations are not a reflection of anticipated monetary or fiscal policies. A large unpredicted element remains in exchange rate behaviour, since fluctuations in currency values have been erratic and seemingly not related to fundamentals (Dropsy and Nazarian-Ibrahimi, 1994).

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4 This definition comes from the online dictionary INVESTOPEDIA.
4 Empirical methodology and data

Thirty years ago, Granger and Newbold (1974) first pointed out that using non-stationary macroeconomic variable in time series analysis causes “spurious regression” problem. Ever since Nelson and Plosser (1982) empirically demonstrated the issue of unit root of such variables, this important property of time series data has been generally accepted. Many studies including Engle and Granger (1987) have lately proved that majority of macroeconomic and financial time series variables are non-stationary or integrated of order 1. Accordingly, a unit root test should precede any empirical research employing such kind of variables.

Cointegration, developed initially by Granger (1981), is a technique used to study the existence of an equilibrium relationship between two time series data. The standard technique of cointegration overcomes the problem of nonstationarity and allows for an investigation into both the levels and differences of exchange rates and stock prices (Phylaktis and Ravazzolo, 2005).

If the two underlying variables, stock prices and exchange rates are cointegrated, then the next step is to explore the short-run relationship between these two variables through Error Correction Model (ECM). ECM can be estimated by Original Least Squares (OLS).

If the two data series are not cointegrated, their stationarity have to be induced before investigating the contemporaneous relationship between these two variables.

4.1 The Augmented Dickey-Fuller (ADF) test

There has been a selection of proposed methods for implementing the stationarity test. The formal method to test the stationarity of series is the unit root test. Principally Augmented Dickey-Fuller (ADF) test and Phillips-Perron (PP) test have been widely used in econometric literature. The ADF test consists of estimating the following regression:

$$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \sum_{i=1}^{m} \alpha_i \Delta Y_{t-i} + \epsilon_t$$

(1)

Where $\Delta$ is the first-differenced operator (i.e., $\Delta Y_t = Y_t - Y_{t-1}$); $Y_t$ is a macroeconomic variable such as exchange rate or stock price; $\Delta Y_{t-1} = (Y_{t-1} - Y_{t-2})$; $\beta_1$ is a drift term; $t$ is a trend variable; $\epsilon_t$ is a pure white noise error term and $m$ is the lagged values of $Y_t$ that are included to allow for serial correlation in the residuals.

For this study, ADF tests are conducted for both stock prices (denoted as $S_t$) and exchange rates (denoted as $E_t$). Testing the null hypothesis of the presence of a unit root in $S_t$ or $E_t$ (i.e. the series is I(1)) is equivalent to testing the hypothesis that $\delta = 0$ in equation (3). Therefore, the hypothesis is constructed as follows,
$H_0: \delta = 0$ and $S_t$ or $E_t$ is said to possess the unit root property if one fails to reject $H_0$, that is, the time series is nonstationary.

$H_1: \delta < 0$, that is, the time series is stationary.\(^8\)

Dickey and Fuller (1979) have shown that under the null hypothesis, $\delta = 0$, the estimated $t$ statistic of the coefficient of $Y_{t-1}$ in equation (1) follows the Dickey-Fuller (DF) distribution.

If both $S_t$ and $E_t$ are stationary ($d = 0$), the classical simple linear regression model is appropriate and its residuals must be stationary. If both $S_t$ and $E_t$ are integrated of the same order ($d > 0$), it is useful to test for cointegrating relationship between the integrated variables. If the underlying variables $S_t$ and $E_t$ are integrated of different orders, e.g. $S_t \sim I(0)$ and $E_t \sim I(1)$, regression equations using such variables are meaningless.

4.2 Engle-Granger (EG) test

Stock (1987) pointed out that if two variables are cointegrated, the regression of the endogenous variable against the exogenous variable would produce super-consistent\(^9\) and highly efficient estimates of the parameters. Hence, cointegration tests are important in determining the presence and nature of an equilibrium economic relation.

The residual-based test of Engle-Granger is a two-step procedure involving an OLS estimation of the specified cointegrating regression model, and a unit root test of the residuals saved from the first step.

4.2.1 The cointegrating regression model

As this paper is designed to explore the contemporaneous effect of the foreign exchange rate movements on stock market behaviour, the following cointegrating regression model on two variables $S_t$ and $E_t$ is studied,

$$S_t = \alpha + \beta E_t + u_t \tag{2}$$

where the slope parameter $\beta$ is known as the cointegrating parameter, $S_t$, $E_t$ and $u_t$ denote the stock index, exchange rate (units of Swedish krona per euro) and error term respectively.

The null hypothesis is $H_0: \beta = 0$ versus the alternative hypothesis $H_1: \beta \neq 0$.

Since there is strong possibility of the raw data $S_t$ and $E_t$ being individually nonstationary, the regression results are likely to be spurious. (Granger and Newbold, 1974)

4.2.2 The unit root test on residuals

Then the next step is to test for the error term through performing a unit root test on the residuals ($\hat{u}_t = S_t - \hat{\alpha} - \hat{\beta} E_t$) obtained from the above cointegrating regression (2).

$$\Delta \hat{u}_t = \gamma \hat{u}_{t-1}$$

\(^8\) As $\Delta Y_t = Y_t - Y_{t-1}$, equation (3) can be written as $Y_t - Y_{t-1} = \beta_1 + \beta_2 t + \delta Y_{t-1} + \sum_{i=1}^{m} \gamma_i \Delta Y_{t-i} + \epsilon_t$, thus $Y_t = \beta_1 + \beta_2 t + (\delta + 1) Y_{t-1} + \sum_{i=1}^{m} \gamma_i \Delta Y_{t-i} + \epsilon_t$. According to stationarity, $\delta + 1 < 1$, so $\delta < 0$.

\(^9\) Superconsistency: estimated coefficients from cointegrated regressions will converge at a faster rate than normal (we need fewer observations than usual).
Notice that this regression has no constant term and the estimated t value of the coefficient of \( \hat{u}_{t-1} \), \( Y \), follows the Dickey-Fuller (DF) distribution.

The following hypothesis is tested:

\[ H_0 : Y = 0 \quad \text{(a unit root exists in } u_t) \]
\[ H_1 : Y < 0 \quad \text{(}\sim I(0)\text{)} \]

The null hypothesis of no cointegration is rejected if the t value is found to be more negative than the critical value, indicating the residuals are stationary. Otherwise, the two series are not cointegrated.

Provided that the residuals to be checked from regression equation (2) are \( I(0) \) or stationary, then the traditional regression methodology (including the t and F tests) is applicable to data involving nonstationary time series. Accordingly, the estimated value of cointegrating parameter \( \beta \) in equation (2) would be valid and meaningful to explain the cointegrating regression, namely, the equilibrium relationship between the two variables.

If the underlying variables \( S_t \) and \( E_t \) are integrated of same orders \( (d > 0) \), but the residual sequence from the cointegrating regression contains a stochastic trend, that is, not stationary, then the regression is spurious. In such situation, both \( S_t \) and \( E_t \) should be induced to be stationary by differencing them in \( d \) times before applying the regression methodology to study their contemporaneous relationship.

As Granger (1986, p.226) notes, “A test for cointegration can be thought of as a pre-test to avoid ‘spurious regression’ situations.”

### 4.3 Error Correction Model (ECM)

Granted that the two variables are cointegrated, it only suggests that our cointegrating regression model is feasible to estimate a long-run, or equilibrium relationship between the two data series. Nevertheless, shocks can move the long-run relationship off track, thus, we are not always at equilibrium. Therefore, an Error Correction Model has to be estimated.

An important theorem, known as the Granger representation theorem states that if the two variables \( Y_t \) and \( X_t \) are cointegrated, then the relationship between the two can be expressed as

\[
\Delta Y_t = \alpha_0 + \alpha_1 \Delta X_t + \alpha_2 (Y_{t-1} - \alpha - \beta X_{t-1}) + \varepsilon_t
\]

Where \( \Delta \) as usual denotes the first difference operator, \( \varepsilon_t \) is a random error term, and \((Y_{t-1} - \alpha - \beta X_{t-1}) = u_{t-1}\) is the one-period lagged value of the error term saved from equation (2) which corrects for deviations from equilibrium, \( \alpha_1 \) is the impact of the short-run changes in \( X_t \) on the short-run changes in \( Y_t \), \( \alpha_2 \) is usually referred to as the speed of adjustment coefficient and is expected to be negative according to theory. A large absolute value of \( \alpha_2 \) is associated to a large value of \( \Delta Y_t \). The absolute value of \( \alpha_2 \) decides how quickly the equilibrium is restored. However, if \( \alpha_2 \) is zero, the change in \( Y \) would not respond to the deviation from long-run equilibrium in the (t-1) time period at all.

Since the variables are estimated in first difference, it is modelling the short-run dynamics of the original long-run (equilibrium) model (equation (2)) and it relates deviations from
equilibrium to changes to the dependent variable. The error correction mechanism\textsuperscript{10} is a means of reconciling the short-run behaviour of an economic variable with its long-run behaviour.

### 4.4 Data

To examine whether stock prices and exchange rates are related using monthly time-series data from Sweden, OMX Stockholm All Share (OMXSPI) index and the nominal bilateral exchange rate between Swedish krona and euro (SEK/Euro) are employed. The OMX Stockholm All-Share or OMX Stockholm PI is a stock market index including all the shares traded on the Stockholm Stock Exchange (SSE). Thus it is the most appropriate index to reflect the current status and changes in the market. To track the performance of the Swedish stock market, the end of month values of the OMXSPI indices by Stockholm Stock Exchange, denominated in local currency, Swedish krona is used.

Several concerns arise with regard to the use of exchange rate data in this study. First, to prevent possible averaging-out effects, employing trade-weighted exchange rate indices or average exchange rates are avoided (Glaum et al, 2000). The domestic currency can appreciate against one foreign currency and depreciate against another foreign currency at the same time, making the weighted index or monthly averages unchanged even there are huge fluctuations in foreign exchange market, so using a bilateral exchange rate is more appropriate. Second, the nominal exchange rate is utilized following the rationale that low volatility of inflation rates implies that any change in the nominal exchange rate level will directly translates into changes in the real exchange rate level. Also, foreign trade in euro currency certainly accounts for a larger weight than the trade volume in any other currency of Sweden’s trading partners. In consequence, it is finally determined to use the monthly bilateral exchange rates of Swedish krona against euro for this research.

The stock indices are obtained from \textit{NASDAQ OMX}\textsuperscript{11} and exchange rates are retrieved from ecowin database with original source from Reuters. All data series are subject to be transformed into natural logarithms, thus their first differences correspond to the growth rates\textsuperscript{12}.

This study covers the sample period from March 31, 2001 to March 31, 2011 for a total of 121 observations being included.

\textsuperscript{10} For more details on how error correction mechanism works, see Gujarati (2004, p.825).

\textsuperscript{11} \url{http://www.nasdaqomxnordic.com/indexes/historical_prices/?Instrument=SE0000744195} retrieved on April 2, 2011.

\textsuperscript{12} According to the log growth rate rule, $g(Y) = \ln Y_t - \ln Y_{t-1}$. A log growth rate is a continuous rate of growth. It is a rate of continuous compounding.
5 Empirical results and analysis

5.1 Test for stationarity of the variables

At first, the Augmented Dickey-Fuller (ADF) test is employed to determine the stationarity of the said variables. The tests are conducted in three cases, without constant (intercept), with constant and with constant and trend. Also, the tests are performed for the entire sample on both the levels and first differences of the stock price indices and exchange rates series in their natural logarithmic forms. The lag length determined by applying the Schwarz Information Criterion (SIC) in the unit root tests is allowed to vary across the exchange rates and stock indices to mop up any serial correlation in the residuals. Reimers (1992) finds that the SIC shows a better performance in selecting the lag length than AIC (Akaike Information Criterion) and HQ (Hannan-Quinn information criterion).

Table 1 Unit root test results

<table>
<thead>
<tr>
<th>Variables</th>
<th>ADF Test results</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Levels</td>
<td>First Differences</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$t_{nc}$</td>
<td>$t_c$</td>
<td>$t_{ct}$</td>
<td>$t_{nc}$</td>
<td>$t_c$</td>
</tr>
<tr>
<td>$\ln S$</td>
<td></td>
<td>0.61</td>
<td>-0.84</td>
<td>-2.08</td>
<td>-9.46*</td>
<td>-9.43*</td>
</tr>
<tr>
<td>$\ln E$</td>
<td></td>
<td>-0.14</td>
<td>-1.84</td>
<td>-1.69</td>
<td>-11.30*</td>
<td>-11.26*</td>
</tr>
<tr>
<td>Critical values</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1%</td>
<td></td>
<td>-2.58</td>
<td>-3.49</td>
<td>-4.04</td>
<td>-2.58</td>
<td>-3.49</td>
</tr>
<tr>
<td>10%</td>
<td></td>
<td>-1.62</td>
<td>-2.58</td>
<td>-3.15</td>
<td>-1.62</td>
<td>-2.58</td>
</tr>
</tbody>
</table>

Notes:
1 subscripts nc, c, and ct denote, respectively, that there is no constant, a constant, and a constant and trend term in the regression.
2 Using critical values by Fuller, 1976.
3 Optimal lag length is selected based on minimum Schwarz Information Criterion (SIC).
4 * denotes significance at the 1% level.

Table 1 presents the results of the ADF tests and the respective critical values at 1% and 10% significance levels in three cases for the natural logarithm of stock price indices and exchange rates. The left-hand-side column of the table presents the test statistics for the level of the data series, and the right-hand-side column presents the test statistics for their first differences. As may be noted from the left-hand-side, using the 10% significance level, the null hypothesis of unit roots cannot be rejected in the original data (levels). This indicates that both series are non-stationary.

While the right-hand-side column of Table 1 shows that the test statistics for the null hypothesis of nonstationarity of the first differences of the two types of data series can be rejected in all cases at the 1% significance level. These results illustrate that both variables are stationary in first differences, which are consistent with most economic time series, suggesting that those series are usually not stationary and integrated of order 1. It is now concluded that both series are integrated of the same order, $S_t \sim I(1), E_t \sim I(1)$. This is a necessary, but not a sufficient condition for cointegration. Subsequently, the empirical analysis
can proceed to the second step, testing for cointegration between stock price indices and exchange rates.

### 5.2 Test for cointegration

Having recognized that both series exhibit I(1) behaviour, the next step is to make use of the cointegration test to find the presence of any cointegrating relationship between stock price indices and exchange rates.

Following the Engle-Granger two-step procedure, the first step is to run the cointegrating regression identified in equation (1). As both the dependent variable and independent variable are transformed into natural logarithmic forms, it turns out to be a type of model referred to as the log-log model. These models provide useful interpretations of the coefficient estimates, as small changes in a logged variable approximate a percentage change in the variable being logged. Therefore, an useful interpretation is given in the form of elasticity of S with respect to E (a 1% increase in E results in a $\beta$ % increase in S).

The regression result is as follows,

\[
\ln S_t = 5.75 - 0.09 \ln E_t \tag{5}
\]

\[
t = (4.84) (-0.17)
\]

Since $S_t$ and $E_t$ are individually nonstationary, there is the possibility that this regression is spurious. Then the second step is to perform a unit root test on the residuals saved from the above regression, the following result is obtained:

\[
\Delta \hat{u}_t = -0.02 \hat{u}_{t-1}
\]

\[
t = (-0.85)
\]

According to Dickey-Fuller distribution, the 10% critical value for n = 120 (total 120 observations after adjustments) is approximately −1.61. Since the computed $t$ value is much less negative than this, the null hypothesis of the existence of the unit root could not be rejected. Therefore, the conclusion is that the residuals from the regression of $S_t$ on $E_t$ are nonstationary, suggesting that the underlying two series are not cointegrated. As no cointegration relationship is present, the estimated model (equation (5)) would (in contrast to cointegrated relationships) be inconsistent and biased. Hence it is not meaningful to interpret the relationship between stock price indices and exchange rates based on the estimated test results from the cointegrating regression.

As the results of the test using the Engle-Granger methodology indicated that no cointegration exists between the variables, the Error Correction Model cannot be applied to investigate their short-run relationships. The ECM is based on the validity of the cointegrating regression model constructed previously.

### 5.3 Test for contemporaneous relationship of stock price and exchange rate

Since both variables are integrated of order 1, the regression model is further applied by taking the first differences of the natural logarithm of stock price indices and exchange rates to capture the expected reaction of Swedish stock market to exchange rate changes.

The following regression result is reported,
\[ \Delta \ln S_t = 0.0035 - 0.89 \Delta \ln E_t \quad (6) \]
\[ t = (0.65) \quad (-2.85) \]
\[ p - \text{value} = (0.52) \quad (0.005) \]
\[ R^2 = 0.06 \]

Since the \( p \)-value 0.005 is less than 0.01, the null hypothesis of \( \beta = 0 \) can be rejected at the 1% significance level. Hence, it is concluded that a linear relationship exists between \( \Delta \ln S_t \) and \( \Delta \ln E_t \). That is, using the log growth rate rule, there is a negative linear relationship \( \beta = -0.89 < 0 \) between the growth rates of stock prices and exchange rates in the long-run. The growth rate of stock price index (OMXSPI) corresponds to the market return of Swedish stock market and the growth rate of exchange rate here represents the depreciation rate of Swedish krona against euro. The test result suggests that, an increase in the depreciation rate of Swedish currency against euro will result in a decrease in the Swedish market return. Specifically, a 1 percentage increase in the exchange rate (SEK/Euro) will approximately lead to a 0.89 percentage decrease in the market stock return.

A diagnostic checking is needed to detect whether there is an autocorrelation problem in the residuals. Since \( d \) statistic can only be used to detect the first-order autoregressive scheme, and one assumption of the \( d \) test that the regressors are nonstochastic is usually difficult to maintain in economic models involving time series data, Hayashi (2000) contends that the Durbin-Watson statistic may not be useful in econometrics involving time series data. The Breusch-Godfrey (BG) test developed by Breusch (1979) and Godfrey (1978) is proved to be more powerful for detecting autocorrelation as this developed test allows for stochastic independent variables and higher order autoregressive schemes. Accordingly, the next step is to test for autocorrelation based on methodology. If the autocorrelation problem presents in the error terms of the regression model, the OLS estimator \( \hat{\beta} \) will no longer be efficient, implying that \( \hat{\beta} \) is not BLUE (Best-linear unbiased estimator), even it is still linear unbiased as well as consistent.

### 5.4 Test for autocorrelation

The Breusch-Godfrey (BG) test to detect the autocorrelation in residuals involves the following steps,

The first step is to save the residuals from the estimated original regression equation (6), thus \( \hat{\epsilon}_t = \Delta \ln S_t - (0.0035 - 0.89 \Delta \ln E_t) \).

The second step is to run the following regression and obtain \( R^2 \) from this auxiliary regression.

\[ \hat{\epsilon}_t = \alpha_1 + \alpha_2 \Delta \ln E_t + \bar{\rho}_1 \hat{\epsilon}_{t-1} + \bar{\rho}_2 \hat{\epsilon}_{t-2} + \cdots + \bar{\rho}_p \hat{\epsilon}_{t-p} + \epsilon_t \]

where \( \hat{\epsilon}_{t-1}, \hat{\epsilon}_{t-2}, \ldots, \hat{\epsilon}_{t-p} \) are the lagged values of the estimated residuals in the first step.

The null hypothesis \( H_0 \) to be tested is,

\[ H_0: \rho_1 = \rho_2 = \cdots = \rho_p = 0 \] meaning that no autocorrelation of any order up to \( p \) exists in the residuals.

Note that the reason that the original independent variable \( \Delta \ln E_t \) is included in this model is to allow for the fact that \( \Delta \ln E_t \) may not be strictly nonstochastic. Also, the number of
data-points available for the above regression depends on the number of lags of the error term (p), hence this regression only has \((n - p)\) observations.

Breusch and Godfrey have proved that,

\[
(n - p)R^2 \sim \chi_p^2
\]

That is, asymptotically, the test statistic \((n - p)R^2\) obtained from the auxiliary regression follows the chi-square distribution with \(p\) degrees of freedom. If \((n - p)R^2\) exceeds the critical chi-square value at the chosen level of significance, the null hypothesis is rejected, in which case at least one \(p\) is significantly different from zero.

As the value of \(p\), the length of the lag cannot be specified a priori, the Schwarz Information Criterion (SIC) could be used to determine the lag length.

In this case 3 lags minimized SIC in the linear original model. Therefore, 3 lags are to be introduced in the auxiliary regression. The following regression result is obtained,

\[
\hat{u}_t = -0.0003 + 0.16\Delta \ln E_t + 0.09\hat{u}_{t-1} - 0.05\hat{u}_{t-2} + 0.21\hat{u}_{t-3}
\]

\(t = (-0.06) (0.51) (0.97) (-0.49) (2.31)\)

The test statistic \((n - p)R^2 = (120 - 3) \times 0.05 = 5.85\). The respective critical values of chi-square distribution at three standard significance levels for df = 3 are presented in the Table 2 below.

<table>
<thead>
<tr>
<th>Degrees of freedom</th>
<th>Pr</th>
<th>0.10</th>
<th>0.05</th>
<th>0.01</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td></td>
<td>6.25</td>
<td>7.82</td>
<td>11.35</td>
</tr>
</tbody>
</table>

Since 5.85 is less than 6.25, the null hypothesis cannot be rejected at 10% significance level, suggesting that no significant autocorrelation exists in the residuals (at least up to lag-order 3 that was chosen with the help of SIC).

To generate a better interpretation, the regression equation (6) might be viewed as the simple linear regression framework developed by Adler and Dumas (1984) to estimate the economic exchange rate exposure of aggregate market-level. In other words, from this perspective, the slope coefficient from the above regression of stock market returns on exchange rate returns can be explained as a measure of the Swedish market’s exchange rate exposure. That is, the economic exchange rate exposure coefficient \(\beta\) represents the sensitivity of the stock market returns to the rates of changes in exchange-rate. A positive value of \(\beta\) means that a depreciation of domestic currency corresponds to an increase in the overall value of the stock market (vice versa for negative value).

According to the regression result, the overall Swedish market’s economic exposure to currency variations is negative and statistically significant at 1% level, implying that an appreciation of Swedish krona against euro leads to an increase in the value of Swedish stock market portfolio.
5.5 Discussions

This result might spark the interest to explore the reason why the dynamic interaction between these two markets in Sweden behaves in this way, why the overall Swedish economy is negatively exposed to the variations in exchange rates of SEK/Euro. Typically, classical exchange rate exposure theory states that a depreciation in home country currency will help the home country firms and hurt foreign firms. Especially, multinational enterprises and export-oriented firms are expected to be benefited from the depreciation of the domestic currency since the decrease in the value of the domestic currency makes exporters more price competitive. Thus, a positive value of economic exposure coefficient seems to make more sense than a negative one for an export-dominant economy. Following the previous research findings, Entorf and Jamin (2002) identified that the company’s degree of involvement into international business and the level of the exchange rate are two important factors in explaining the exposure. Doukas et al. (2003) discovered that significant exposures, which are higher in the case of multinational and exporting companies, are also positively related to the degree of international involvement of the firm but negatively linked to the firm’s size and its financial leverage. In addition, both El-Masry (2003) and Kyimaz (2003) found that the direction and the magnitude of significant exposures to exchange rate risk depend to a large extent on the industry.

Based on the discussion above, for an individual firm, the economic currency exposure relies much on the currency structure of its exports, imports and financing. Therefore, depreciation of domestic currency can either raise or lower a firm’s stock prices depending on whether, or to what extent the firm is a user of exported or imported inputs. If the firm is involved in both activities, stock prices could move in either direction, as explained by traditional approach in the theory section. While the estimated economic exposure here is measuring an aggregated effect of all the listed firms embodied in the market portfolio, and this study does not investigate the characteristics of all the firms traded on the Stockholm Stock Exchange, it is not possible to provide a comprehensive explanation on the reasons behind the negative correlation between those two variables.

Even though a clear illustration is hard to given from the firm-level perspective, the result can still be explained in macroscopical sight. From the foreign trade market viewpoint, it might be expected that most Swedish industries are with substantial multinational involvement with imports for their production. Consider at this point, Swedish krona depreciation increases the cost of production due to large imports of raw materials from abroad, especially from the euro zone area, which in turn hurt firms’ profits and result in a drop in the value of the whole stock market. From the capital market viewpoint, a depreciation of Swedish krona against euro makes investors lose their confidence on the competitiveness of krona. To avoid further declines in returns in euro term, a large number of investors may decide to withdraw their investments from Swedish equity market, causing a string of stock market sell-offs.

To sum up, it can be concluded that there is a statistically significant impact of foreign exchange rate changes on the stock market returns in Sweden, and an appreciation of Swedish currency against euro will lead to a contemporaneous increase the value of the whole Swedish stock market.

The information about the details of all the above test results is summarised in Table 3 presented in the Appendix.
6 Conclusion and further suggestions

This research empirically examines the contemporaneous relationship between stock prices and exchange rates in Sweden for the period from March 2001 to March 2011.

To begin with, absolute values of the two monthly time-series data were converted into natural log forms and checked for stationarity. Augmented Dickey-Fuller (ADF) test was applied and the results showed that both series are stationary at their first differences. Then the Engle-Granger (EG) methodology was employed to test whether these two series are cointegrated, and the result indicated no cointegrating relationship exists in the two underlying variables. Consequently, for the purpose of further regression analysis, the natural logarithms of the two data series were transformed into first-differenced forms.

The result of testing the contemporaneous relationship of stock price and exchange rate showed that changes in the value of Swedish krona against euro would lead to a contemporaneous change in the value of the Swedish stock market to the opposite direction. Based on this empirical evidence, it can be concluded that Swedish stock market and foreign exchange market are negatively related. In other words, an appreciation of Swedish krona against euro leads to an increase in the value of Swedish stock market portfolio.

For further research suggestions, as this paper only estimates the contemporaneous relationship between the said variables, this study can be extended to an in-depth investigation on their causal dynamic linkages through conducting a Granger causality test. As a note of caution, the standard Granger causality test can only be applied in the absence of any cointegrating relationship between the said variables. If the two variables are cointegrated, an error correction term should be included in the bivariate autoregression to test their Granger causality relationship. Additionally, different frequencies of data used might lead to different empirical results. Daily data is supposed to contain more information but also more noise, so weekly data could be considered for further study within this topic.

A point that also deserves attention is the question that why the overall Swedish economy is negatively exposed to the variations in the bilateral exchange rate of SEK/Euro. Thereby, the economic exchange rate exposure tests and analysis at firm or industry level can be conducted afterwards so as to provide a more convincing explanation on their negative association. Whether firms use financial hedging to reduce their exchange rate risk could also be further examined.
References


### Appendix

Table 3 summary results of the tests

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>t-statistic</th>
<th>Std. Error</th>
<th>p-value</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cointegration test</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.000250</td>
</tr>
<tr>
<td>Intercept</td>
<td>5.748453</td>
<td>4.844604</td>
<td>1.186568</td>
<td>0.0000</td>
<td></td>
</tr>
<tr>
<td>ln E</td>
<td>-0.091373</td>
<td>-0.172608</td>
<td>0.529365</td>
<td>0.8633</td>
<td></td>
</tr>
<tr>
<td><strong>Unit-root test</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.002433</td>
</tr>
<tr>
<td>( \hat{u}_{t-1} )</td>
<td>-0.016443</td>
<td>-0.849706</td>
<td>0.019351</td>
<td>0.3459</td>
<td></td>
</tr>
<tr>
<td><strong>Contemporaneous relationship test</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.064628</td>
</tr>
<tr>
<td>Intercept</td>
<td>0.003479</td>
<td>0.647236</td>
<td>0.005376</td>
<td>0.5187</td>
<td></td>
</tr>
<tr>
<td>( \Delta \ln E )</td>
<td>-0.892875</td>
<td>-2.855346</td>
<td>0.312703</td>
<td>0.0051</td>
<td></td>
</tr>
<tr>
<td><strong>Breusch-Godfrey test</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>-0.000322</td>
<td>-0.060011</td>
<td>0.005372</td>
<td>0.9523</td>
<td></td>
</tr>
<tr>
<td>( \Delta \ln E )</td>
<td>0.160435</td>
<td>0.505440</td>
<td>0.317416</td>
<td>0.6142</td>
<td></td>
</tr>
<tr>
<td>( \hat{u}_{t-1} )</td>
<td>0.090472</td>
<td>0.970424</td>
<td>0.093229</td>
<td>0.3339</td>
<td>0.051865</td>
</tr>
<tr>
<td>( \hat{u}_{t-2} )</td>
<td>-0.045129</td>
<td>-0.486065</td>
<td>0.092845</td>
<td>0.6279</td>
<td></td>
</tr>
<tr>
<td>( \hat{u}_{t-3} )</td>
<td>0.213779</td>
<td>2.312292</td>
<td>0.092453</td>
<td>0.0226</td>
<td></td>
</tr>
</tbody>
</table>