# THE EFFECT OF CURRENCY MOVEMENTS ON STOCK MARKETS

A Thesis

by

TATEVIK ZOHRABYAN

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

December 2005

Major Subject: Agricultural Economics

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# ABSTRACT

The Effect of Currency Movements on Stock Markets. (December 2005)

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Chair of Advisory Committee: Dr. David A. Bessler

This paper uncovers the relationship between stock markets and exchange rates in seven countries by employing stable aggregate currency (SAC) for the period of 1973-2004. Ordinary Least Squares (OLS) regression, time series methods, and directed acyclic graphs are applied to the daily data on stock market indices and exchange rates. The findings based on regression analysis show that exchange rate exposure of stock markets is statistically significant when stock indexes in SAC are used. Using an innovation accounting technique, we confirm that stock markets and exchange rates are correlated. Moreover, in most cases stock markets are more exogenous than foreign currency markets, which explains the relatively high percentage of uncertainty in the foreign currency market. Overall, SAC-based models give relatively more accurate and robust results than those which employ stock indices in local currencies, because it is more accurate to convert both variables into the same denominator.

## ACKNOWLEDGEMENTS

Many people have given of their time to make this thesis possible. Special thanks go to Dr. David Bessler for his invaluable and unconditional support and encouragement throughout my research. Thanks go also to Dr. James Kolari for his never-ending guidance and perceptive insight throughout this research process. I would also like to express my gratitude to Dr. John Nichols who has been a constant source of motivation, and whose suggestions have been extremely helpful in the completion of my thesis.

I am honored to have been one of the recipients of the USDA Scholarship, and for which I would like to thank Dr. Daniel Dunn and Mr. Tim Grocer who gave me the opportunity to gain valuable knowledge and experience in one of the foremost universities in the world. The support, inspiration, and encouragement I received from Dr. Verne House is also greatly acknowledged and appreciated. Many others also contributed to the successful completion of my research, namely Susan Livingston and Vicki Heard, to whom I am sincerely grateful.

Ultimately, I am thankful to God, without whose intervention, this opportunity to further my life's goal could not have been realized.

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# CHAPTER I

# INTRODUCTION

Recently there has been some evidence questioning the efficiency of stock markets. Theoretically, the efficiency of stock markets suggests that all information known by market participants is already included in stock prices. Stock markets represent the properties of a random walk, which suggest that there is no predictable pattern in daily returns. Returns change depending on the daily news, events, economy, etc. However, after careful examination of the stock market data and macroeconomic variables on the economy in general, researchers seem to have some doubts that the stock market cannot be predicted or explained by other variables (Campbell and Ammer, 1993). Markets have changed over time. Forty to fifty years ago, stock market participants were primarily individual investors; now about 80% of participation is by institutional investors who are interested in companies' performances over time, short-term gains, etc. (Yaes and Bechhoefer, 1989).

Various macroeconomic variables have been included in models of stock market behavior, among which money supply, inflation, interest rates, price level, and exchange rates are most commonly used. Moreover, it has been about two decades since the relationship between exchange rates and stock markets became an important new area for researchers to investigate.

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This thesis follows the style and format of the *American Journal of Agricultural Economics*.

The fact that exchange rates are at least a few times more volatile than inflation justifies increasing interest by academics as well as investors in general. Although exchange rates are much more volatile, most researchers failed to find any causal effect on stock market fluctuation (the causal effect of other macroeconomic variables might be very critical for stock market fluctuations; however, it is beyond the scope of the objective of this thesis).

A few studies found a weak relationship between the two financial markets, which was justified theoretically in two different ways. One of the causal relationships arises when “the expected value of the currency influences domestic and foreign interest rates, which in turn affects the present value of a firm’s assets (Nieh and Lee, 2001).” Eventually, the economy as a whole is affected by exchange rate movements. Secondly, currency value determines the foreign sales of companies[1]. For example, a decrease in the value of the domestic currency relative to foreign currency intensifies domestic exports, which promotes the competitiveness of domestic companies in the market. As a result, a company’s share value increase, followed by an increase in foreign investments. Consequently, aggregate stock market values will increase. The theoretical and empirical analyses on this matter have been investigated by economists for over two decades.

[1] Only the companies that have both foreign and domestic sales are referenced. However, the domestic firms might be affected by the exchange rate fluctuations if the prices of inputs, outputs, and demand for their product is influenced by currency movements.

**1.1 Problem Statement**

Because both foreign currency markets and stock markets are important indicators of economy-wide performance, much attention has been given to modeling both markets. Specifically, several studies have focused on the relationship between exchange rates and stock markets with some additional control variables. Their results support the evidence that exchange rates and stock markets are weakly correlated to each other, which implies that exchange rates are not useful tools to predict stock market movements. Conversely, few studies have suggested that stock markets cause exchange rate movements (i.e. unidirectional causality from stock markets to exchange rates). Overall, empirical investigations found in the literature show considerable heterogeneity with respect to the type of exchange rate studied, the choice of the base currency, additional control variables, and method of analysis. Not surprisingly, various results have been found.

The choice of the base currency plays a crucial role in estimating the exchange rate exposure. The majority of the researchers used either the US dollar or other countries' currencies, or a trade-weighed exchange rate index as a base currency. Use of a particular country's currency as the base suffers from  currency fluctuations indicating a high exchange rate risk. For example, if US$/yen is used as an exchange rate where the US dollar is the base currency, then changes in the yen will be reflected only against the US dollar, which is perhaps different from the actual change of yen on a global basis (against some stable value). Conversely, the trade-weighted exchange rate index, which is computed based on exchange rates at some fixed proportions, is more stable compared to the individual currencies. Each country's total trade with the US (US dollar is a base currency) indicates the proportion of that particular currency's weight in the exchange rate index. Consequently, the weights of the currencies will change due to the changes of $i^{th}$ country's trade ratio with the US over time. As a result, the value of the trade-weighted exchange rate index will change. All the previous studies used models where stock market prices or indices were in local currencies, while exchange rates were denominated in some basket or individual currency. This creates a mismatch between the right-hand-side and left-hand-side variables, thus providing spurious results. Both the exchange rate and stock market index encompass exchange rate risk, which minimizes the volatility if the exchange rate term creates an unbalanced model. In addition, the problem of exchange rate volatility is associated with achieving a minimum volatility for both terms.

The International Monetary Fund (IMF) created the Special Drawing Rights (SDR), which is a basket or aggregate of key international currencies to address the problem of exchange rate volatility. The SDR minimizes the effects of volatilities of comprised currencies on the SDR aggregate by combining them at some fixed proportion. This aggregate (SDR) was proposed to make the exchange rate movements more stable over time. The goal of stable exchange rates is to facilitate more stable cash flows from international transactions, and therefore, to reduce the need to hedge exchange rate risk. Foreign investments would become more intense once there is reduced exchange rate risk. Multinational corporations with numerous branches are also sensitive to the volatility of exchange rates. Such volatility creates an extra obstacle in predicting future cash flows. It is of great interest to be able to decrease volatility and make more accurate predictions about business operations.

In 2003 a new basket of currencies, called the stable aggregate currency (SAC), was proposed by Hovanov et al. (2003). SAC is similar to SDR, as it is comprised of several key international currencies. Through empirical analyses, they found that the SAC is both stable over time and not highly correlated with the key international currencies included in the basket. As countries seek to stabilize exchange rates movement, utilization of SAC would be a worthwhile avenue for consideration.

Because studies investigating the relationship between exchange rates and stock market values have employed mostly volatile exchange rates, results are perhaps spurious. According to some studies, exchange rates are not correlated with stock market returns. Others supported the evidence of weak correlations. This result may be because of the double exchange rate risk included both in stock market returns and exchange rate terms.

### 1.2 Objective

This study examines the effect of currency movements on stock markets by employing the SAC. Unlike previous studies, both stock market indices and exchange rates are denominated in the same basket of currency (SAC) in order to minimize the exchange rate risk and have an accord in a model. Utilization of the SAC will give precise estimation of the relationship between the exchange rates and the stock markets for the period January 1973 to November 2004. In order to attain the main objective, rate of return in stock price indices and rates of return in exchange rates are analyzed by both OLS regression and more sophisticated time series methods. In addition, causality will be examined through Directed Acyclic Graphs (DAG).

A couple of supporting models are used in the study. First, rates of return in stock index prices are regressed on the rates of return on the corresponding exchange rates with both series converted into SAC. Second, rates of return on stock index prices in local currencies with the same control variables are used to compare the difference between the results based on the utilization of SAC. Third, rates of return of all the exchange rates (in this study it is seven) in SAC are used as control variables with the same rate of return on stock index prices in SAC. Fourth, rates of return on stock index prices in local currencies are regressed on the same group of control variables. After the regression models, a cointegration test will be applied to determine the long run relationship and the bidirectional causality between the above mentioned series.

**1.3 The Relationship between the Previous Studies and This Thesis**

Most prior studies have found non-significant exchange rate exposures that are either negative or positive due to the different model specifications or time horizons used by the studies. On the other hand, significant exposure was found by some researchers. Some studies have also observed no relationship between the two variables. Omission of some important macroeconomic variables has accounted for the non-significant exposure estimates. Financial derivatives, used by most firms with both domestic and multinational natures, helped to reduce their risk exposure. This risk reduction is already reflected in their stock prices, which conceals the true exchange rate exposure of firms. This fact accounts for the insignificance of the exchange rate exposure estimate (Chow et. al., 1997). In general, currency fluctuations matter so much that the results can change significantly.

By employing SAC, which is very stable over time (almost fixed), our analysis reveals that exchange rates have significant negative effects on stock markets. Because the exchange rates are presented as the local currencies per SAC, the depreciation of a local currency indicates an increase of the exchange rate. Therefore, a negative exposure coefficient along with an increased exchange rate will lead the stock markets to fall in value instantaneously, perhaps due to the indirect effect of interest rates and exports/imports. Exchange rate exposure coefficients are different from zero and actually, they are near -1 when rates of return on stock index prices are converted into SAC. In addition, very high coefficients of determination ($R^2$) result from the utilization of SAC. On the other hand, when rates of returns of stock index prices are in local currencies, most exposure coefficients are not significantly different from zero, yielding low $R^2$. The direction of the contemporaneous relationship between the two variables is not systematic in these cases (models based on local currencies).

In addition to the results on a daily basis, monthly data has been employed to test the sensitivity of the exposure coefficients to the time horizon. Results show that monthly data doesn’t yield robust results, perhaps because monthly data averages out the daily high-low volatility, leaving relatively smoother volatilities in both series.

The remainder of this thesis is organized as follows: Chapter II discusses the literature review. The data and methodology along with the models are outlined in Chapter III. Chapter IV introduces the results based on both OLS regression and time series analyses. Chapter V contains conclusions and a summary.

# CHAPTER II

# LITERATURE REVIEW

A large number of researchers have focused on studying the interactions between the financial markets. Recently, the research concentration has shifted to studying the relationships of two highly volatile financial markets: the stock markets and the foreign currency markets. Results vary from study to study; however, the majority of them fail to show significant causal relationship between the two. The analyses were expanded to the firm/industry level, which had no effect on the outcomes. Macroeconomic variables, such as the interest rates, the inflation rate, the money supply, etc., were added to models that included only stock markets and exchange rates, to reassess the effect of the exchange rates on stock markets and vice versa. This too did not render a sizable change in the outcomes.

## 2.1 The Relationships between Stock Markets and Exchange Rates

For the past few decades, the relationship between exchange rates and stock markets has been given much attention in the academic literature.  Studies have attempted to determine how one financial market can predict the others and vice versa. Several studies found that stock markets and exchange rates are strongly correlated. However, the results are not robust across specifications. For instance, Aggrawal (1981) used monthly U.S. stock prices and effective exchange rates for the period from 1974 to 1978. The study attempted to determine the relationship between changes in stock indices and changes in dollar exchange rates under a floating exchange rate regime. The results show that stock prices and U.S. exchange rates are positively correlated and stronger over a short term horizon than over a long term horizon. Conversely, Soenen and Hannigar (1988), using monthly stock prices and U.S. effective exchange rates for the period from 1980 to 1986, noted that stock prices and the value of the U.S. dollar are negatively correlated. Using monthly data on stock prices and exchange rates for nine developed countries, Solnik (1987) showed that depreciation of currency has a positive, yet insignificant, impact on the U.S. stock prices.

Interestingly, stock markets are also claimed to influence foreign currency markets. Moreover, it is one of the most important determinants of exchange rate movements (Babarumshah et al. (2002)). This notion is consistent with studies that showed the existence of unidirectional causality from stock markets to the exchange rates (Ibrahim (2000), Bahmani-Oskooee and Sohrabian (1992), and Qiao (1997)).

Trade flows, the type of the economy, the monetary system, and time horizons, as well as other variables seem to affect the relationship between stock markets and the exchange rates. Ma and Koo (1990) demonstrate that if the economy is export-oriented, then the appreciation of the domestic currency will negatively affect the domestic stock price movements. The stock price movements of an import-oriented economy would be positively affected by the appreciation of the domestic currency. Employing monthly data from nine leading Asian markets for the period from January 1980 to June 1998, Mohsin and Amare (2000) found that whether stock prices are negatively or positively impacted by the exchange rates depends on the time horizon, trade flow elasticity, and the underlying monetary system. In terms of the time horizon, they offer that in the short-run depreciation of a currency negatively affects the economic activity and stock market returns through the outflow of financial resources. Conversely, the impact in the long run is positive as the depreciation promotes exports that improve stock markets.

Johnson and Soenen (2004) uncover the effects of U.S. equity markets on the value of the U.S. dollar, which in turn determines whether U.S. equity investments for foreign investors change depending on the U.S. dollar changes. Their data, covering the period from 1971 to 2002, is comprised of daily observations of the stock market index (S&P 500) and seven foreign currency values of the U.S. dollar.[2] To determine the contemporaneous or lead/lag relationship between the stock market index and the exchange rate (FC/US$), the Geweke feedback measure is employed.[3] The findings show that the significance of the exposure estimates changes for each U.S. dollar structural change (i.e. strong or weak U.S. dollar period). Moreover, weak and non-consistent relationships during weak dollar periods but very strong positive relationships between S&P 500 and the dollar value exist during strong dollar periods. This notion confirms that non-domestic investors in the U.S. stock market face compounding exchange rate risks. Overall, in contemporaneous time, stock market movements and the exchange rate changes are correlated with each other. However, no lagged effect exists

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[2] Those seven currencies used in Johnson and Soenen (2004) are the British pound, Canadian dollar, French franc, German mark, Italian lira, Japanese yen, and Swiss franc.
[3] Both restricted and unrestricted equations have been used for Geweke feedback measure estimation. The former one is expressed by the regression equations where stock market index is regressed on exchange rate changes and the lagged value of the stock market index, and vice versa. The latter case includes few assumptions associated with the OLS regression.

between the U.S. stock market and the value of the U.S. dollar, which confirms no unidirectional causality (Granger – type causality) exists between the two variables

Bahmani-Oskooee and Sohrabian (1992) studied bidirectional causality between changes of exchange rates and stock prices by employing the Granger causality test and standard (Engle and Granger) cointegration techniques on monthly U.S. stock market index and effective exchange rates in dollars for the period July 1973-December 1988. In the short-term horizon, bidirectional causality exists between exchange rate and the U.S. stock market index. However, in the long-run, they reported no relationship between these two variables. Qiao (1997), on the other hand, utilizing daily data on stock prices and exchange rate relationship for Japan, Hong Kong, and Singapore, reported that in the long run the three countries are strongly integrated; however, the casual flows between the stock market and the exchange rate across the countries differ.

Currencies of many emerging countries are very sensitive to the U.S. dollar, which explains the instability and high volatility of their financial markets. Abdalla and Murinde (1997) examined the relationship between stock prices and exchange rates for emerging markets such as India, Korea, Pakistan, and the Philippines. Their study covers the period from 1985 to1994 on a monthly basis. Using cointegration techniques, they suggest that stock prices and exchange rates exhibit long run relationships for all the countries except Korea. Overall, they reported unidirectional causality from exchange rates to stock prices for all countries except the Philippines.

As mentioned above, numerous papers investigate the relationship between exchange rates and stock market returns. Almost all report at least slightly different results. Some suggest that exchange rate changes positively affect stock markets, some find negative exposure estimates, while some researchers claim there is no evidence of impact of exchange rate changes on stock market returns. Rapp et al. (1999) found that stock markets and foreign exchange markets are jointly efficient. In other words, no long run relationship exists between these two markets. In order to come to this conclusion, they first used a standard cointegration method to test for a long run relationship, and second, for the purpose of accuracy checking, they used a bivariate common serial correlation to detect comovements between the variables. Neither technique supported comovements between these two variables, which suggest that both markets are jointly efficient.

### 2.2 The Relationships between the Firm/Industry Value and Exchange Rates

In addition to the study of the relationship between stock markets and exchange rates, many studies have focused on exchange rate exposure from a firm's perspective. Exchange rates, being one of the major sources of uncertainty for multinationals, have not had much attention paid to them by researchers as a common cause for a firm's stock price variation. Jorion (1990) was amongst the first to empirically examine the exchange rate exposure of US multinationals or the value of the U.S. firms. Exposure estimate, defined as the sensitivity of the firm value on the exchange rate changes, shows how and in what fashion stock prices are influenced by the foreign currency market movements (Jorion, 1990). Consequently, an increase in value of domestic currency unfavorably affects the exports and favorably affects the imports, thus it has a negative impact on the economy. In order to estimate the exposure coefficient, the rate of return of the company's stock is regressed against the rate of changes of the trade-weighted exchange rate, where the exchange rate term is presented as the US dollar value of the foreign currency (US$/FC), such that the decrease in the dollar value increases the value of a company's stock. Data used by Jorion (1990) covers the period from 1971 to1987 including trade-weighted exchange rates and commons stocks of companies.[4] Only companies with no missing data are considered, yielding a total of 287 U.S. multinationals with and without foreign operations. In addition to the classic exposure model that has only exchange rates as a control variable, an alternative model is examined. In the latter model, Jorion (1990) adds only the value-weighted market index as an additional control variable. Overall, the exposure coefficients from both models are highly correlated. Jorion (1990) found that the degree of a firm's foreign involvement positively affects the exposure estimates. On the other hand, domestic firms without foreign operations have very similar exposures. Overall, there is little support that the exchange rate changes systematically influence stock prices of U.S. firms.

Similarly, Glaum et al. (2000) attempted to answer why previous studies failed to show statistically significant firm exposure to exchange rate movements. Using daily data on stock returns of German corporations and the changes of the exchange rate of Germam mark per U.S. dollar (DM/U.S.) for period from 1974 to1997, Glaum et al. (2000) investigated the effect of the U.S. dollar on German corporations. The total time

[4] The total period is divided into three separate sub-sample periods which are 1971-1978, 1976-1980, and 1981-1987.

period is divided into three sub-sample periods to tackle movement of the U.S. dollar against the German mark. Glaum et. al. (2000) used an exposure model introduced by Jorion (1990), only they used orthogonolized exchange rate returns. Results, based on the total period, show that about 55% of the firms have significant positive exposure supporting the evidence that German firms are favorably affected by the depreciation of the German mark and the vice versa. However, for separate sub-periods the results are unstable and more difficult to economically interpret. In other words, Glaum et al. (2000) found that depending on the time horizon (sub-periods or full period), the results change, but overall, no systematic exposure effect was found. The results are unstable over time which might be explained by the omission of macroeconomic variables.

**2.3 Macroeconomic Variables as Additional Control Variables**

The omission of macroeconomic variables was viewed to be the possible explanation for unsystematic and insignificant results. Researchers got motivated by this idea taking also into consideration the macroeconomic variables for modeling the relationship between the stock markets and the exchange rates.

Bodnar and Gentry (1993) examined the relationship between changes in exchange rates and industry values. They also attempted to uncover the effects of industry characteristics, such as trade ratios, internationally-priced inputs, and foreign investments, on the exchange rate exposure estimate. The contemporaneous relationship between real asset value and real exchange rate is expressed by the exchange rate exposure coefficient, which is usually defined as a measure of the sensitivity of a firm value to the exchange rate changes or the correlation between the two. In their paper, Bodnar and Gentry (1993) used monthly data on G-7 trade-weighted nominal exchange rate, returns on industry portfolios and returns on the national stock market for U.S., Canada, and Japan. For the first two countries the time period extends from January 1979 to December 1988, and for the latter they used the time period from September 1983 to December 1988. Utilizing a model similar to Jorion (1990), where the return on the industry portfolio is regressed against the return on the nominal stock market and percentage change in the trade-weighted nominal exchange rate, Bodnar and Gentry (1993) found that in all three countries, between 20 to 35 percent of the industries reveal statistically significant exchange rate exposure. The sign of the exposure is different depending upon the nature, the size and the foreign operations of the industry. Overall, exchange rate movements to some extent help to determine the industry returns at an economy-wide level.

The significance of the exchange rate and industry shocks for industries in five developed countries is examined in Griffin and Stulz (2001). Using weekly data on returns for industry, market returns, and exchange rate changes for the U.S., Canada, U.K, France, Germany, and Japan for the time period from January 1973 to June 1997, they showed that only about 12 industries worldwide out of 300 have great exchange rate exposure. The analyses are conducted based on the “classic” regression model where stock returns are regressed on the exchange rate changes and the alternative one that includes market returns. In both models, the exchange rate variable is expressed as the value of local currency per foreign currency (HC/FC). The results show that exchange rates are insignificant in explaining the variations of industry returns. The results remained the same even after several specifications, such as time lengthening, alternative model specification, and alternative return definition.

Employing daily closing stock market indices and foreign exchange rates for the time period from October 1993 to February 1996, Nieh and Lee (2001) examined both short-run comovements and long-run equilibrium relationships between stock prices and exchange rates for each G-7 country: Canada, France, Germany, Italy, Japan, the United Kingdom (U.K.) and the US. All the exchange rates are vis-à-vis US dollar (FC/US$). Both Engle-Granger two steps and the Johansen maximum likelihood cointegration tests are employed to check for the robustness of the results. Their findings suggest no long-run equilibrium relationship exists between stock prices and exchange rate. However, in the short-run the two markets have a one-day predictive power in certain countries. For example, in Italy and Japan stock prices negatively influence the exchange rates with a one-day lag, while in Canada, the U.K. and Germany exchange rates lead the stock markets with one-day lag. Interestingly, stock markets and exchange rates are significantly uncorrelated in the United States in both short-run and long-run horizons. Overall, for each G-7 country stock market movements are independent of foreign currency movements in the long run and neither of the two has predictive power over the other in the long run.

Monthly trade-weighted exchange rate indices and returns on portfolios for the time period from January 1980 to August 1992 are employed to determine the foreign currency exposure of the thirty-nine largest exporting firms in the U.K.. By regressing the return on the portfolio of exporting firms against the trade-weighted exchange rate of pound, Donnelly and Sheehy (1996) demonstrated a contemporaneous relationship between the two variables. They reported significant negative exposure estimates associated with the high explanatory power of the model. Moreover, stock prices of the firms tend to incorporate the exchange rate shocks within some time lag (i.e. the exporting firms react to the changes in exchange rates with a few-day lag).

Using multiple exchange rates instead of the most commonly used trade-weighted exchange rates, industry and firm levels separately vs. either industry or firm level, all the possible firms and industries vs. multinationals or large exporting companies, equally weighted vs. value-weighted market returns, Dominguez and Tesar (2001) explored the exchange rate exposure for eight countries, Chile, France, Germany, Italy, Japan, the Netherlands, Thailand, and the U.K.. They used weekly returns, country-specific market portfolio returns, and three country-specific exchange rates for the total period from January 1980 to May 1999 with three sub-samples. The findings show about 14%-31% of the sample firms and between 11%-60% of the sample industries in the eight countries have exchange rate exposure. The sign of the exposure differs across countries. Overall, Dominguez and Tesar (2001) found contemporaneous relationships between firm values and exchange rates, as well as the return on industry portfolio and the exchange rates in all eight countries.

He and Ng (1998) examined the effect of the changes in exchange rates on the value of the Japanese multinational corporations. In addition to the common models where contemporaneous relationships between the two variables is investigated, He and

Ng (1998) attempted to demonstrate the effect of the lagged exchange rate changes on the value of the firms under the study. One hundred seventy-one Japanese multinational corporations that satisfy the condition of 10% of export ratio are employed along with the Japanese value-weighted market portfolio and the rate of changes in a trade-weighted exchange rate index.[5] In order to estimate the exchange rate exposure, the rate of return on each corporation's stock is regressed against the rate of return on a trade-weighted exchange rate index at both current and lagged levels, and the rate of return on a market portfolio. The exchange rate is expressed as the yen price of foreign currency such that depreciation in Japanese yen will favorably affect the Japanese multinationals by making the companies more competitive in an international market. The results show that for the whole period from January 1979 to December 1993 about 25% of the multinationals have significant positive contemporaneous exposure; however, lagged exchange rate changes have insignificant effect on the stock returns for the sample period. The findings also show that the extent of the exposure depends on the export ratio, short-term liquidity position, and the firm size.

Patro et al. (2002) shed light on explaining the determinants and the significance of the exchange rate exposure for equity index returns by employing GARCH specification. Employing weekly world market portfolio returns and the trade-weighted exchange rate index for 16 OECD countries for the period from 1980 to 1997, Patro et

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[5] The trade-weighted exchange rate index is commonly used in many studies including Jorion (1990), Bodnar and Gentry (1993), He and Hg (2001). Weighted averages of nine bilateral (in some studies the number of bilateral exchange rates changes depending on the preferences of authors) exchange rates, expressed as Japanese yen value of foreign currency for Australia, Canada, France, Germany, Italy, Netheralnds, Switzerland, UK, and US, are taken to construct the trade weighted exchange rate index where weights represent countries' trade ratio to total trade with Japan.

al. (2002) reported significant time-varying foreign exchange rate exposure, which changes across countries.[6] In addition, they demonstrate the determinants of exchange rate exposures. As a result, imports, exports, credit ratings, taxes, inflation, and government surplus all have an aggregate effect on the currency risk exposure.

Only a few period studies reported statistically significant relationships between exchange rates and stock returns. Attempting to investigate how and in what fashion the exchange rates and bond and stock returns are correlated, Chow et al. (1997) regressed the asset rate of return against the trade-weighted exchange rate index, dividend yield or default premium, and the term premium. In addition, in short-run analysis, an additional dummy variable is included to increase the explanatory power of the exchange rate exposure model. For observation period of March 1977 to December 1989, Chow et al. (1997) claim that in long-run about 50% of the variations in stock returns and 20% of the variations in bond returns are explained by business conditions. Moreover, bond returns have significant positive exposure in both the long-run and short-run. On the other hand, stock returns are more sensitive to the time horizon used. As a result, in the long-run stock exposure to exchange rate movement is significantly positive, while there is no statistically significant correlation between the two in the short-run. Positive exposure coefficient indicates that the dollar depreciation will increase the U.S. firms' competitiveness in the world market and thus will favorably affect the share price of US

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[6] The 16 OECD countries are Australia, Austria, Belgium, Canada, Denmark, France, Germany, Italy, Japan, Netherlands, Norway, Spain, Sweden, Switzerland, UK, and US. All the index prices are in their respective local currency.

firms. Dividend yield, term premium, and default premium all influence temporal variations of excess returns.

### 2.4 Time Horizon and Model Structure

To address the importance of model structure and the return horizon in the exchange rate exposure estimates on the stock prices, Bodnar and Wong (2003) employed monthly data on stock prices/returns for 910 U.S. firms, U.S. dollar trade-weighted indices, other macroeconomic variables (portfolio market value ($), firms in portfolio, firm market values, and foreign sales) for the period from 1977 to 1996. With regard to the time horizon, consistent with previous studies, results indicate that longer time horizons give more accurate exposure estimation; however, one should be cautious when the time horizon extends even further than the sample size.

Several researchers consider the question of what other macroeconomic factors they might include in the exposure regression. Different macroeconomics factors including interest rates, money reserve, inflation, different monetary policies, etc., have been applied to the exchange rate exposure model by various researchers.

By using a macroeconomic variable in addition to stock prices and exchange rates, Ajayi et al. (1996) suggested that stock prices affect the exchange rates by increasing the demand for real money. Earlier, Solnik (1984) claimed that stock prices might influence exchange rates when studied with other macroeconomic variables.

On the other hand, Ibrahim (2000) has suggested that the choice of a market portfolio in the exposure model has a significant impact on the exchange rate exposure estimates. He used monthly data on the stock market index and 3 exchange rates (real effective, nominal effective, and end-of-the-month exchange rates) for Malaysia covering the period from 1979 to1996. To capture the effect of model specification on the exposure estimates, bivariate and multivariate models are examined; in the latter case, money supply (M2) and reserves are considered, in addition to three exchange rates. Employing a cointegration test and Granger causality, Ibrahim (2000) found no long-run relationship between the stock market index and any of the exchange rates in the bivariate models; however, in a multivariate model there is some evidence of cointegration. His findings suggest that in the long run, the stock market is cointegrated with other variables, while in the short-run, changes in money supply and reserves affect the returns. One of the recent studies, Bodnar and Wong (2003), also support the importance of time horizon, the choice of the variables in the model, and the firm size. When firm return or stock price of an individual firm is regressed against the exchange rate change, results are not robust depending on time and return horizon. Omitted variables are present in the model structure of exposure estimates. Exchange rate exposure tends to differ depending on the construction of the market portfolios. Bodnar and Wong (2003) also noted a significant inverse relationship between firm size and exchange rate exposure. No matter the extent of a firm's involvement in exchange-rate-sensitive activities, the results suggest that the smaller the firm, the more positive exchange rate exposure it incurs; on the other hand, large firms have negative exposure to the value of the U.S. dollar. Overall, Bodnar and Wong (2003) claimed that firm-level exchange rate exposure depends on the construction of the market portfolio.

## 2.5 The Contribution of This Study to the Literature

The common link between these studies and this paper is the focus on the relationship between stock markets and exchange rates. This study will determine the long-run relationship between stock markets and exchange rates employing not local currencies, but the stable aggregate currency (SAC) that is comprised of all the countries' currencies used for the study. The SAC is stable over time and has the least standard error compare to other currencies. Besides Hovanov et al. (2003), who constructed SAC and showed its stability and negligible volatility, Maung (2004) applied the SAC to a real world application trying to investigate the structure of dynamic interdependence of nine stock markets for the US, Canada, the U.K., Germany, Switzerland, Italy, Belgium, Japan, and Hong-Kong. He also shows that converting stock market indices into SAC greatly minimizes the exchange rate risk associated with the currency fluctuations. Applying time series methods and DAG for the period from January 1973 to February 2003, Maung (2004) reported that the exchange rates understate (overstate) the stock market variations depending on whether a currency appreciates (depreciates) over time relative to a basket of currencies. Therefore, it is very important to minimize or eliminate the currency fluctuations in stock markets. That has been possible by using SAC to transform the stock market index, which results in a global stock price. In other words, the stock returns are the same for all the investors around the world. Conversion of stock market indices into SAC yields very stable results and exhibits the least correlation between the nine markets.

This paper attempts to explore another area of SAC application, which will allow investors and businesses to have a clear picture of how exchange rates are tied to the stock markets. Applying SAC instead of a single currency, researchers will be able to decrease the exchange rate risk associated with cash flows, boosting the increase in the precision of cash flow forecasting. In general, this study will show how stable currency alters the relationship between stock markets and exchange rates.

# CHAPTER III

# DATA AND METHODOLOGY

In order to get correct and robust results, stationarity of data has to be maintained. Both stock market indices and exchange rates need to be expressed in the same denominator, the stable aggregate currency (SAC), which is computed based on the variance minimization framework. This serves the purpose of the study by minimizing the exchange rate risk in both stock market indices and exchange rates. Further, the local currency-based and SAC-based models were created to enable them to be analyzed and compared.

## 3.1 Data

The data used in this study consists of daily stock market indices and exchange rates for Japan, the U.K., Germany, France, the Netherlands, Italy, and the US. The data were obtained from two different sources: stock price indices are obtained from the DataStream databank, and the exchange rate data are obtained from the Federal Reserve Bank. The period under study begins January 1, 1973 and ends November 19, 2004. This time period was chosen because of the data availability; further, within this time frame many important events happened such as regime changes, stock market crashes, the creation of the euro, terrorist attacks, etc. The sample period is split into two separate periods: first, the pre-euro period starting January 1, 1973 to December 31, 1998; second, the euro period starting January 1, 1999 to November 19, 2004.

Most of the stock indices used in this study represent large, mostly exchange listed stocks, and they represent large market capitalization in their respective financial markets. These stock indices are Nikkei 225 Average Composite Index (Japan), FTSE 30 Ordinary Index (U.K.), DAX 30 Performance Index (Germany), DS Total Market Index (France), AEX 30 Ordinary Index (Netherlands), DS Total Market Index (Italy), and S&P 500 Composite Index (US). The exchange rates include the Japanese yen, British pound, German mark, French franc, Netherlands guilder, Italian lira, and US dollar. From January 1, 1999, the euro was used instead of the German mark, French franc, Netherlands guilder, and Italian lira. All these exchange rates are vis-à-vis the base-currency, the US dollar.

### 3.2 Stable Aggregate Currency

The value of exchange rates, expressed as one currency per other currency, changes depending on currencies used. In literature regarding international economics and finance, as well as in real world practices, analyses involving different currencies usually are conducted using one base currency or numeraire. Depending upon the choice of the base currency, the dynamics of the resulting time series change dramatically as a result of currency fluctuations over time. In essence, the exchange rate fluctuates due to the fluctuations of both currencies. Regarding this matter, the choice of base currency is critical to obtain a stable exchange rate. For example, using the U.S. dollar as a base currency as opposed to the British pound changes the relationship between the euro and yen (Hovanov et al., 2003).

To address the base currency problem, an invariant currency value index (ICVI)[7] is proposed by Hovanov et al. (2003). ICVI is found to be independent of base currency choice. The value of index of a currency will not change depending on the usage of different base currencies. In a sense, for a fixed set of currencies the ICVI is the same regardless of base currency choice. The usage of ICVI as a base currency enables researchers to demonstrate fluctuations of any currency on a global market.

Normalized value in an exchange or a normalized index of value (*NVal)* in exchange is used to mathematically express the ICVI through the following formula:

$$(1) \qquad NVal_{ij} = \frac{c_{ij}}{\sqrt[n]{\prod_{r=1}^{n} c_{ij}}}$$

where $NVal_{ij}$ is the normalized value in exchange, $c_{ij}$ is the exchange coefficient or the exchange rate of the $i^{th}$ currency for the $j^{th}$ currency, and where $j^{th}$ currency is the base currency. The geometric mean of values in exchange (i.e. $c_{ij}$) is expressed by the following term $\sqrt[n]{\prod_{r=1}^{n} c_{ij}}$ . In this study we use seven currencies, therefore $n$ would indicate the number of the currencies ($n$=7), and $i$=1,…, $n$, so we would have seven exchange rates ($c_{1j}$, $c_{2j}$, …, $c_{7j}$). Regardless of the base currency choice, the normalized value in exchange $NVal_{ij}$ is the same for each base currency chosen, therefore $NVal_i$ can substitute $NVal_{ij}$ for the rest of the study. The time series of all the currencies' rates of exchange are observed employing $NVal_i$. Reduced normalized value in exchange

[7] Simple exchange model (SIMEX) is used as a conceptual and mathematical framework for constructing the invariant index of currency's value in exchange. For more details on this regard, it is recommended to read the article grounded by Hovanov et. al. (2003).

($RNVal_i(t/t_0)$) is used instead of $NVal_i$ because of the convenience of further demonstration.

$$(2) \qquad RNVal_i(t/t_0) = \frac{NVal_i(t)}{NVal_i(t_0)}$$

Equation (2) expresses the reduced (to the moment $t_0$) normalized value in exchange starting from $t_0$ which can be set as $t_0 = 1$, where $i = 1,\ldots,7$ in this study.

Time series of reduced (to the moment $t_0 = 1$ or the starting day-January 1, 1973) normalized values in exchange for seven countries are computed as: USD(t/1)=RNValUSD(t/1), JPY(t/1)=RNValJPY(t/1), GBP(t/1)=RNValGBP(t/1), DEM(t/1)=RNValDEM(t/1), FRF(t/1)=RNValFRF(t/1), ANG(t/1)=RNValANG(t/1), ITL(t/1)=RNValITL(t/1), where t=1, …, 6784 for the pre-euro period, and t=1,…, 1536 for the euro period, total of 8320 moments.

Index of value in exchange is mathematically constructed as follows:

$$Ind(w;t) = \sum_{i=1}^{n} w_i RNVal_i(t/t_0)$$

where the index of value in exchange is presented in the form of reduced normalized values in exchange $RNVal_i(t/t_0)$, $i = 1,\ldots,7$, $t = 1,\ldots,6784$ and $t = 1,\ldots,1536$ for the pre-euro and euro periods respectively, and $w$ is the weight vector used to determine the index ($w = w_1 + w_2 + \ldots + w_7 = 1$).

In order to obtain the stable aggregate currency (SAC), which is comprised of seven currencies in this study, optimal currency weights are used. The latter will be attained by minimizing the variance $S^2(w)=var(w)$ subject to the constraint:

$$w_i \geq 0, i = 1,\ldots,7, w_1 + w_2 + \ldots + w_7 = 1$$

where weight-coefficients $w_1,\ldots,w_7$ are determined by the expression

$$w_i = \frac{q_i c_{ij}(t_0)}{\sum_{r=1}^{7} q_r c_{rj}(t_0)}$$

The variance $S^2(w)$ can be presented as:

$$S^2(w) = \sum_{i,k=1}^{7} w_i w_k \operatorname{cov}(i,k) = \sum_{i=1}^{7} w_i^2 s_i^2 + 2\sum_{\substack{i.k=1 \\ i<k}}^{7} w_i w_k \operatorname{cov}(i,k)$$

where cov(i, *k*)is the covariance of time series $RNVal_i(t/t_0)$, $RNVal_k(t/t_0)$, and $s_i^2$ is the variance of the time series $RNVal_i(t/t_0)$, *i*, *k* =1,…,7, *t* =1,…,6784 and t=1,…,1536 for the pre-euro and euro periods respectively. The optimal weight coefficients are obtained by minimizing the variance ($S^2(w)$) subject to the constraints. Then, optimal weight coefficients can be used to obtain the optimal amount of currencies ($q_1$*,…, $q_7$*) through the following equation:

$$q_i^* = \frac{w_i^*}{c_{ij}(t_0)}\mu$$

where $\mu$ can be expressed as:

$$\mu = \sum_{r=1}^{7} q_r c_{rj}(t_0)$$

Because the sum of currencies optimal amounts is one, then we can derive $\mu$ from that equality:

$$q_1^* + q_2^* + \dots + q_7^* = 1 \Rightarrow (\frac{w_1^*}{c_{1j(t)}} + \dots + \frac{w_7^*}{c_{7j(t)}})\mu = 1$$

$$\Rightarrow \mu = \frac{1}{(\frac{w_1^*}{c_{1j(t)}} + \frac{w_2^*}{c_{2j(t)}} + \dots + \frac{w_7^*}{c_{7j(t)}})}$$

Given all the necessary parameters, $\mu$ is computed, which is later used to compute the optimal currency amounts ($q_i$*'s).

Stable aggregate currency is a basket of currency (in this study it is comprised of seven currencies) that incorporates currencies at fixed proportions in the basket. The proportions or amounts of the currencies are computed through the above listed mathematical expressions. However, recently an easier way to compute those weights has been used. Grounded on Hovanov et al. (2003), a web-based program supports the calculation of optimal weights and currency amounts and also provides exchange rates for local currencies per SAC.[8]

### 3.3 Procedure

After computing the SAC, which, in this study, is comprised of seven currencies at assigned proportions, it will be employed for further analyses. Because SAC is more stable over time and less correlated with the individual currencies in the basket, it is used as a base currency or numeraire for our study. Technically, SAC application as base currency dramatically minimizes the exchange rate risk and thus implies a reduced need to hedge international transactions. SAC can also be used to minimize the currency risk

[8] For further details about the SAC computation process through the web-based program, visit www.isc.tamu.edu/~bharath/sac.

in the stock market index. Once the exchange rates for local currency per SAC are computed, stock market index prices in local currencies can be transformed into stock market index prices in SAC. All the mathematical equations mentioned in the SAC Section are used to get exchange rates for local currencies per SAC. The conversion of stock index prices in local currency into stock index prices in SAC is expressed through the following equation:

$$R_{it}^{SAC_t} = R_{it}^{Currency_t} \times \frac{SAC_t}{Currency_{it}}$$

where $R_{it}^{SAC_t}$ and $R_{it}^{Currency_t}$ are stock index prices in the SAC and local currencies respectively, i=1,…, 7 is the number of stock countries, and t =1,..., 6784 for the first sub-period (the pre-euro period) and t=1,..., 1536 for the second sub-period (the euro period), yielding a total of 8320 observations (i.e. 01/01/1973-11/19/2004). Finally, $\frac{SAC_t}{Currency_{it}}$ is the exchange rate of $i^{th}$ country's local currency for the SAC at time t. All converted stock indices and exchange rates are transformed into natural logarithms. Hereafter, OLS regression and cointegration methodology is applied to these time series data.

**3.4 Model Specification**

To avoid spurious results, both series have to satisfy a stationarity condition. Series are called stationary if their mean and variance are stable over time. Both exchange rates and stock price indices exhibit unit root or so-called nonstationary patterns. There are several techniques to overcome the nonstationarity problem. One of the simplest techniques is to difference the series until they are stationary (Mjelde, et al.

2002). In this study, the first difference is used to sustain stationarity of series. Appling the first differences of the series in the OLS regression will yield robust and correct results.[9]

Rate of change in exchange rates and rate of return on stock price indices are used as stationary data. Both monthly and daily data is used to test for the goodness of the model. For the purpose of estimating the exchange exposure of the stock markets, which represents the sensitivity of the stock markets to the exchange rate changes, the rate of return on stock price indices are regressed on the rate of change in the exchange rates (Jorion, 1990).The exchange rate is measured as the local currency value of the base currency, the SAC. This allows us to show the net value of the local currencies (seven local currencies) in the world not just against another local currency, because the SAC is very stable over time, representing almost a fixed value (Hovanov et al., 2003).

To estimate the exchange rate exposure of the stock markets four different regression models are used. The models are designed to exhibit the differences between SAC returns and local currency returns. The first two models are expressed the following way:

$$(3) \qquad R_{it}^{SAC_t} = \alpha_{0i} + \alpha_{1i} E(\tfrac{Currency_t}{SAC})_t + \varepsilon_{it}$$

$$(4) \qquad R_{it}^{Currency_t} = \beta_{0i} + \beta_{1i} E(\tfrac{Currency_t}{SAC})_t + \varepsilon_{it}$$

where $R_{it}^{SAC_t}$ and $R_{it}^{Currency_t}$, as mentioned above, are the rates of return on stock index prices in the SAC and local currencies respectively, $\alpha_{0i}$ and $\beta_{0i}$ are intercepts or

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[9] The time series model section will discuss the stationarity problem in depth.

constants in those two models, $\alpha_{1i}$ and $\beta_{1i}$ represent stock markets sensitivity to the exchange rate fluctuations for the two models respectively, $E(\frac{Currency_i}{SAC})_t$ is the rate of changes in exchange rate of i$^{th}$ countries' local currency for the SAC, and finally $\varepsilon_t$ is the error term in both markets, for i=1,…,7 and t=1,…,6784 for the first sub-period and t=1,…, 1536 for the second sub-period, yielding total of 8320 observations.

Model 3 represents the relationship between stock index prices and the changes in respective exchange rates in SAC for all seven markets. Utilization of SAC as a common currency for asset denomination greatly minimizes the exchange rate risk of the stock returns. More specifically, SAC denominated stock market indices are called global market returns as they are identical for a domestic and foreign investor (Hovanov et al., 2003). Model 4, on the other hand, includes double exchange rate risks expressed in both exchange rate term and stock market indices in local currencies. In fact, the true exchange rate effect on the stock market is obscure and cannot be accurately measured. Although the same control variables are used in both models, the exposure coefficients are significantly different. Both models show the effect of changes in exchange rates on stock markets with and without exchange rate risk. The two models show the relationship between the stock markets and exchange rates only within i$^{th}$ country, where i represents the number of countries in this study (i=7).

The second half of the model is similar to those above with the difference of the number of control variables.

$$(5) \qquad R_{it}^{SAC_t} = \alpha_{oi} + \sum_{j=1}^{6} \alpha_{1ij} E(\frac{Currency_{ij}}{SAC})_t + \varepsilon_{it}$$

$$(6) \qquad R_{it}^{Currency_{it}} = \beta_{0i} + \sum_{j=1}^{6} \beta_{1ij} E(\tfrac{Currency_{ij}}{SAC})_t + \varepsilon_{it}$$

Unlike models 3 and 4, these models represent the total effect of all the seven exchange rates on the i^th^ stock market. The sensitivity of the i^th^ stock market to the other countries exchange rates, is measured by the exposure coefficients $\alpha_{1ij}$ and $\beta_{1ij}$ in both models respectively. The exchange rate term is similar to the first two models, only they are extended to seven different currencies, where *j* is the number of other exchange rates used. The rest of the equation is exactly the same as in the previous two models.

The purpose of having the exact models with the only difference of the assets denomination is to compare and contrast the exposure coefficients as they change due to the exchange rate fluctuations. For all the models, both monthly and daily data is applied to test the sensitivity of the results to the time horizon. To check which model is better, a residual squared error ($R^2$) is considered. The higher the $R^2$ of the model, the more likely that the model is accurate. However, considering only $R^2$ would not give a complete and clear picture of which one is better. At 5 % significance level, t-statistics are computed which is then tested against the critical value of t-statistics[10]. If the computed t-statistics is less than the critical value, then changes in exchange rates have no significant effect on the stock market indexes and vice versa. The significant exposure coefficient implies that stock market movements are affected by the exchange rate changes. OLS regression gives only a contemporaneous correlation between the rate of return in stock market indices and the rate of change of exchange rates. However, to explore the dynamic

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[10] Critical value is1.96 at 5% significance level.

relationship the between the two, a Johansen (1991) cointegration test are used in the next section.

### 3.5 Time Series Models

Before the cointegration tests are conducted, there is a need to test for the stationarity of the series.[11] The null hypothesis of the unit root test (the same as a stationarity test) states the nonstationarity of the series. Table 1 gives Dickey-Fuller test on stationarity. Because stock index prices and exchange rates are nonstationary at levels and stationary at first differences, it is important to check for the integration of the two series. Based on prior studies, stock markets are correlated with the exchange rates to some extent, which implies that the two series are linked together. Even though the series are nonstationary, which makes it hard to predict either of the two, integration will enable the two series to move depending upon each other's movements. However, unsystematic results of the priori studies motivate us to check for the integration of the series, or more formally said, to see whether the two series are cointegrated.

Suppose stock index prices are denoted as $Y_t$ representing a vector of m nonstationary I(1) processes where m=7. The VAR of order k is expressed by the following equation:

$$(7) \qquad Y_t = \alpha + \sum_{i=1}^{k} A_i Y_{t-1} + \varepsilon_t$$

[11] Stationarity of the series will indicate that data series eventually return to their historical mean and have constant variance over time.

where $Y_t$ is an $m \times 1$ vector with m=7 representing the seven stock market indexes used in this study. $A_i$ and $\alpha$ are (7 x 7) coefficient matrices, and $\varepsilon_t$ is a (7 x 1) innovation vector. Equivalently, error correction model (ECM) can be presented based on VAR component in first differences with the order of k-1:

$$(8) \qquad \Delta Y_t = \alpha + \sum_{i=1}^{k-1} \Gamma_i \Delta Y_{t-i} + \Pi Y_{t-1} + \varepsilon$$

$$\text{where } \Pi = \sum_{i=1}^{k} A_i - I \ ; \ \Gamma_i = \sum_{j=1}^{n} A_j - I$$

Here Δ represents the first differences, Γi, α, and Π are coefficient matrices with $\alpha$ representing constant, $k$ is the appropriate number of lags. $\Pi Y_{t-1}$ term is to represent error correction component at levels for t=1,…, 8320 of total observation in this study.

A trace test is employed to test for cointegration. The number of cointegrating relations, $r$, can provide preliminary information on the long-run structure of market interdependence. The rank of Π determines the number of cointegrating vectors. Trace test statistics of Johansen (1991) can be computed to test the null hypothesis stating that there are at most r cointegrating vectors ($r = 0, \ldots, 7$) . As a result, if the rank of Π is full ($r = m$), then the $Y_t$ is stationary and VAR at levels is appropriate. If the rank is zero, then that means the series is nonstationary and none of the combinations of the two are stationary at levels. In this case, VAR at first differences can be conducted for analyzing dynamic relationships. Conversely, if the rank is $0 < r < m$, then an r cointegrating vector exists indicating the presence of the r linear combinations of series that make the process stationary, thus ECM can be conducted.

Before conducting a trace test to determine the cointegrating vector *r*, an order of lag (*k*) should be determined. We use Schwartz loss and Hannan and Quinn loss metrics to determine up to how many lags of series should be included in the estimation of VAR at levels. The results of the lag order are reported in Tables 2 and 3. The lag order differs for each association when stock index prices are regressed only on the respective exchange rates. However, when all other currencies are included as control variables, the number of lags are more consistent and on average, they are between 3 for the first test (SL) and 4 for the other one (HQ) in the per-euro period and range between 1-2 in the euro period. It is also interesting to note that the results for lag determination are the same for stock returns in SAC and for those in local currencies.

The computed number of lags is used for each association to perform the trace test. [12] The results of the trace tests are reported in Table 5 where we use only two models and the critical values are reported at 95%. To determine the cointegrating vector r, we use trace tests with only two models: the first model includes constant in the cointegration relations, and the second model includes the first model in addition to the trend in levels (outside the cointegration relations). These two models are the best to use for such data. The null hypothesis of the rank Π is r = 0 at a 5% significance level, which means that no cointegrating vector exits between the two series. The alternative hypothesis of the rank is that $r \geq 1$, indicating that there is at least one cointegrating vector. Our results show (reported in Table 4) that for the model where stock index

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[12] Note that all the time series analysis are conducted using CATS in RATS software grounded on Hansen and Juselius (1995). Also, the critical trace statistic values are taken from the CATS in RATS manual. For this study we only used critical trace statistic values from tables B2 and B3 (pg 80-81).

prices are regressed on all seven exchange rates, for all the combinations there is at least one cointegrating vector for the pre-euro period (January 1973 to December 1998), while no cointegrating vector is found for any of the association of series in the euro period (January 1999 to November 2004). The picture is different when in the regression model only the respective exchange rates are included as control variables (Table 5). Only the association of stock markets and exchange rates in Germany (in the pre-euro period) and in Japan (in the euro period) have one cointegrating vector. The results of trace tests are slightly different for models using SAC returns and the ones with local currencies. However, the decision is the same and the same number of cointegrating vectors is present in both models, therefore we report the trace test results only for models in SAC. Hereafter, the first-differenced VARs will be employed to the series with no cointegrating vectors, and ECM will be conducted for the series with at least one cointegrating vector in the association.

For those series that have at least one cointegrating vector in the space, it is interesting to examine which series are actually included in the cointegration space. A test for exclusion is used, where the null hypothesis is that $R'\beta = 0$ with R' representing a design matrix of zeros and ones placed to exclude the series from the cointegration space (Bessler and Kergna, 2003). If the results indicate that all the series are in the cointegration space, does it mean that in short-run each of the series responds to the perturbations in the long-run relation? A test for weak exogenity is conducted where the decisions are made based on the null hypothesis of $B'\alpha = 0$. Like R', $B'$ is a design matrix with zeros and ones to exclude the series that don't respond to the perturbations in the long-run relations.

Because of the difficulty to interpret individual coefficients of both the ECM (if stock market indexes and exchange rates are cointegrated) and the VAR (if there is no cointegration between stock market indexes and exchange rates), innovation accounting is used to summarize the dynamic relationship between the stock market indices and exchange rates. The parameters of Equation (7) are estimated based on the maximum likelihood procedure of Johansen (1992). An error correction model is expressed as levels of VAR using the estimated coefficients. Later, the innovation accounting is conducted based on the equivalent levels of VAR in order to illustrate the dynamic relationship between the stock market indexes and exchange rates.

To determine the contemporaneous structure of the relationship between stock market indexes and exchange rates, a variance-covariance matrix of innovations from ECM is used. However, in order to get the causal relationship among innovations in contemporaneous time *t*, directed graphs are employed. Further, Bernanke ordering may be used on the structure found with the directed graphs on contemporaneous structure (Bessler and Kergna, 2003). [13]

[13] For in depth information on time series methods, we refer our readers Bessler and Yang (2003), Bessler and Kergna (2003).

**3.6 Directed Graphs**

A directed graph is a picture representing the causal relationship among a set of variables. Lines with arrowheads are used to represent causal flows, such that A→B indicates that variable A causes variable B. However, the causal direction is undetermined if we get A − B. D-separation, which formally represent the screening-off phenomenon, is used to assign the direction of causal flow to a set of variables (Pearl, 2000).[14] Spirtes et al. (1993) have incorporated d-separation into an algorithm (PC algorithm) for assigning casual flows among a set of variables or in other words, for building directed acyclic graphs (i.e. acyclic graph can contain only one of each variable) using the notion of sepset, which is defined as a variable that was conditioned on to remove edges between two variables. The PC algorithm is an ordered set of commands that remove edges from a complete undirected graph by first checking for any relationship between pairs of variables. The edges between variables with no correlations are removed. This checking process continues until all the possible relations among a set of variables are checked. After the first order conditional correlation, the checking process continues for zero second order correlation, and so on up to N-2 order conditional correlation. The PC algorithm is programmed in the software TETRAD II (Scheines et al., 1994).

Note that directed acyclic graphs (DAG) can be used if and only if there are at least three variables. This implies that for the models where stock market indices are regressed on respective exchange rates (i.e. only one control variable) DAG cannot be

[14] For more detailed information about Directed Graphs, we refer our readers Bessler and Yang (2003).

employed. Only models with stock markets and all the exchange rates as control variables can utilize DAG to picture the instantaneous correlation of the innovations at time *t*.

# CHAPTER IV

# RESULTS

This study is differentiated from previous works by the application of more stable base currency, as well as stock market and exchange rates that are expressed in terms of the same denominator. Consequently, the results are different as well. The exchange rate exposure estimates are systematic and significant using the SAC-based model, while the opposite is prominent using the model commonly used by prior studies. Besides these OLS regression results, time series analysis restated the significance of the SAC-based model, relative to the local currency-based model. The causal relationship between the stock markets and exchange rates results in interconnected financial markets using the SAC-based model, and more separated markets with local currency-based model. All of these results are detailed below along with the dynamic interdependence results that show the proportion of one of the financial markets' variance caused by the other, and vice versa.

## 4.1 OLS Results

Previous studies, using local currencies or nominal exchange rates, reported unsystematic results including both negative and positive exchange rate exposure coefficients that were found to be insignificant in some studies and significant in others. Using rate of return in stock index prices and rate of changes in exchange rates in the OLS regression, we found that exposure coefficients dramatically change when stock index prices in SAC are used as opposed to those in local currencies. All the four models (mentioned in the model section) are analyzed on a monthly and daily basis for the pre-euro and the euro periods.

When stock index prices are regressed against the respective exchange rate returns in SAC, the findings show that exchange rate exposure coefficients are significant and negative for all the countries. The coefficients are significantly different from zero and so we reject the null hypothesis which states that the coefficients are equal to zero. $R^2$s are very high which indicates the goodness of the model. The coefficients, significance level, standard errors, and t-statistics are reported in Appendix D (Table 14). For example, when Nikkei 225 in SAC is regressed against yen per SAC, then the exchange rate exposure coefficient is -1.156991 with 0 significance level and -40.31547 t-ratio. This shows that the coefficient is significantly different from 0 and is negative at 10%, 5%, and 1% significance levels.[15] These results are consistent for both the pre-euro and euro periods on a daily basis. Conversely, when stock index prices in local currencies are regressed against the corresponding exchange rates in SAC, the results are similar to the findings of previous studies. The exchange rate exposure coefficients are not different from zero for most parts. For both pre-euro and euro periods on a daily basis, exposure coefficients deviate around zero and statistically are insignificant for the most part. As reported in Appendix D (Table 14), only 4 out of 7 regressions show a significant exposure estimate for the pre-euro period. However, the signs of the exposure coefficients are not systematic. Only for 4 cases out of 7 exposure coefficients are

[15] Note that in our study we use 5% significance level for all the analyses.

negative and for the rest they are positive. For the euro period, only 2 out of 7 are significant and mostly positive. This is consistent with many studies that found positive exposure coefficients using volatile exchange rates; however, similar to many previous studies no systematic results are found. In comparison with the results of model 3, the measure of model goodness ($R^2$) is about 20 times lower when stock returns are in local currencies.

In addition to the regression models comprised of two series, the effect of the exchange rates as a group on stock index prices is analyzed. Alternatively put, stock index prices in both SAC and local currencies separately are regressed on all the seven exchange rates per SAC. Appendix (Table 15) calculates the coefficients, along with the t-statistics and $R^2$s. For the pre-euro period, again, 4 out of 7 exposure coefficients are significant under local currency application, and none of them is significant in the euro period (Table 15). Similarly, the signs of the coefficients are not systematic. For different stock indexes, exchange rate exposure coefficients for all seven countries are different. For instance, when DAX (German Stock Index) is regressed against yen, U.S. dollar, British pound, German mark, French franc, Netherlands guilder, and Italian lira (all of the exchange rates are per SAC) for the time period from 1973 to 1998 on a daily basis, all currencies except for the Netherlands guilder and Italian lira explain the perturbations of the German stock market. The picture is different for euro period. Based on Appendix D (Table 15), exchange rates do not have a significant effect on stock markets except for the U.S. dollar on the Japanese stock market. When stock returns are converted into SAC, the significance and the sign of the exposure coefficients dramatically changes (Table 15). In both the pre-euro and the euro period, coefficients are negative and significantly different from zero. However, the effect of other currencies on stock index prices is the same in both cases. This implies that SAC changes the relationship between stock market and exchange rate only within a country. It defines the true effect of currency value on stock market. It gives more accurate results since there is no double exchange rate risk when SAC is applied.[16] $R^2$s of SAC-based model are again much greater than that of the local currency-based model confirming the goodness of the SAC-based model.

Monthly results are reported in Appendix D (Tables 16 and 17). Overall, monthly results are not as robust as daily results. Conversion of stock index prices into SAC changes the exposure coefficients half of the time and does not yield systematic results. This is because both stock markets and foreign currency markets are volatile on a daily basis. Monthly data smoothes the volatility and results in a less accurate outcome. Therefore, daily data is used for further analyses.

Overall, when stock index prices are converted into SAC the exchange rate risk is eliminated leaving the pure stock return, which is the same for all investors around the world (not including currency changes). However, for the investor in a foreign country, the total return would be the return from investment plus local currency return (Hovanov et al., 2003). Exposure coefficients are significant and negative when SAC is used as a

[16] The stock index prices denominated in local currencies and exchange rates for local currencies per base currency result in a double exchange rate risk. However, when stock index prices are denominated in SAC, the exchange rate risk is greatly minimized to almost none, and the exchange rate for local currency per SAC will show local currency change overall. In this case the actual U.S. dollar effect on stock indices without exchange rate risk would be analyzed to show the real relationship between these two series.

denomination of assets or stock indices. Negativity of the exposure coefficient implies that when currency depreciates, the exchange rate for local currency per SAC increases. This will decrease stock returns in SAC and, thus, the $i^{th}$ stock market will go down. Therefore, we can conclude that both financial markets move in the same direction in contemporaneous time.

## 4.2 Time Series Results

After the determination of the cointegration rank (*r*), which was conducted via the trace test, the associations of stock market indices and all the exchange rates of seven countries have one cointegrating vector in the pre-euro period. Only the association of stock market indices and the respective exchange rates for Germany and Japan have one cointegrating vector for the pre-euro and the euro period respectively (results are reported in Table 8). For these associations of stock market indices and exchange rates, tests for exclusion and weak exogenity are conducted. The results based on the SAC and local currencies are the same for most of the cases. However, the association of stock market indices and all the currencies for the U.S. and stock market index and respective exchange rate for Germany are exemptions. In these cases, the SAC results differ from the results based on the local currencies.

Table 4 shows that for all seven countries, the British pound, German mark and the Netherlands guilder are part of at least one cointegrating vector, while the Japanese yen, U.S. dollar, French franc, and all the stock market indices are not in cointegration space. The Italian lira is part of at least one cointegrating vector for Japan, the U.S., Germany and the Netherlands. Table 5 shows that stock markets and exchange rates in both Germany and Japan are part of at least one cointegrating vector.

Table 7 gives test results for weak exogenity on each model and country. This test shows whether the $i^{th}$ market responds to the perturbations in any of the long-run equilibrium relationships (cointegrating vectors). At a 5% significance level, the Japanese yen and all the stock market indices for most of the countries do not respond to such perturbations. The rest of the series respond by restoring the long-run equilibrium due to new information. The British pound does not respond to such perturbations. Table 8 shows that stock markets and exchange rates in Germany and Japan do respond to perturbations in the long-run equilibrium, with the exemption of the German stock market index when it is denominated in SAC.

Because an innovation accounting technique is not appropriate for the models with stock market indices and respective exchange rates (only one control variable), we use the first-differenced VAR to obtain F-tests along with the p-values at a 5% significance level. However, for the associations that have cointegrating vectors, we use correlation matrices to show the relationship between the stock markets and exchange rates. Table 11 gives the calculated F-tests and p-values at a 5% significance level. For the pre-euro period, the Japanese stock market and the respective currency (JPY) are not correlated, while bidirectional causality exists between stock markets and respective exchange rates in Germany, the Netherlands, and Italy. The U.S. dollar seems to be an important factor for U.S. stock markets, in other words depending upon the currency movements, the US stock markets are significantly influenced. Conversely, the French stock market significantly affects the franc in the pre-euro period. SAC-based results are more robust with a higher significance level. The local currency-based model shows that there is no correlation between the two financial markets in France. Consistent results are found for the euro period where the stock markets of each country are significantly influenced by the respective exchange rates. This result is consistent with the OLS regression results. In addition, for the two counties with cointegrated stock market and foreign currency market we computed the correlation coefficient. Table 13 shows that the two markets have a high negative correlation for SAC-based models and a low positive correlation for local currency-based models.

**4.3 DAG Results**

The results of DAG are found using a PC algorithm at a 5% significance level. Because the financial markets of all the countries operate in different time zones, there is a problem associated with nonsynchronous trading. The latter indicates that markets such as the U.S. stock market that operate after the closing of the Japanese market, cannot influence Japanese markets at time *t* (at contemporaneous time) but can influence them with at least a one-day lag. In order to overcome the problem of nonsynchronism, restrictions are placed. We assume that both financial markets in the U.S. are tier 2 (are the last ones in the world to operate in a given day), all the stock market indices and exchange rates in Europe are tier 1, and those of Japan are tier 0, where tiers indicate the operation time, such that both financial markets (stock market and foreign currency market) operate first in tier 0, followed by markets in tier 1 and tier 2.

Appendix B, Directed Graphs, shows the differences of the models using stock market indices in SAC and local currencies. As mentioned earlier, DAG is used to picture the contemporaneous relationship only among the stock markets and all the exchange rates for both the pre-euro and the euro periods. Note that we could not use DAG to represent the contemporaneous causal relationship between a stock market index and the respective currency.

In the pre-euro period, the Japanese yen is exogenous in contemporaneous time. The shock is transformed to the rest of the world through the Japanese yen (rest of the world is meant to represent the six other countries used in this study). Because foreign currency markets are correlated, changes in the value of one currency would have an impact on the other currency. The yen leads the British pound, Italian lira, French franc, German mark, and the U.S. dollar under all the scenarios. The US dollar, the Netherlands guilder, and the German mark are greatly influenced by almost all other currencies, while the German mark and the British pound influence the value of the US dollar. Within Europe, the Netherlands guilder is the most influenced by almost all other currencies, which indicates that it is an information "sink."[17]

In the first sub-period, the stock market indices and exchange rates are correlated when SAC-based models are used; however, the causal directions change upon each country case. Figure 1 (Directed Graphs) shows that the stock index price and exchange rate in Japan are correlated; however the causal flow is undetermined. Note that the

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[17] The relationship among exchange rates of seven countries is not investigated in and is beyond the scope of this research paper. Therefore, not much elaboration will be devoted to this issue.

results are the same for both the SAC-based and the local currency-based models. On the other hand, unidirectional causality exists from stock market to exchange rate in the U.S. when the stock indices in SAC are used stock indexes in SAC. Conversely, no relationship is found between the two that use a local currency-based model.

Interestingly, European stock markets and exchange rates are more correlated with each other than in the U.S. or Japan. For instance, contemporaneous unidirectional causality exists from both the British pound and the Netherlands guilder to the U.K. stock market (SAC-based model). Interestingly, no causal relation is found between the U.K. stock market and the British pound; instead, bidirectional causality is reported between the US dollar and the U.K. stock market when local currency-based models are utilized. In Germany, the causal flow goes from the stock market to the German mark, as well as to the French franc. Converting the German stock market index into SAC returns eliminates the unidirectional causality from the German stock market to the U.S. dollar. Bidirectional contemporaneous causality is reported in France where the Netherlands' guilder and French franc cause the stock market index and vice versa. Also, the stock market index in France causes the German mark. The picture changes when a local currency-based model is used. It originates a new causal relationship from the French stock market to the U.S. dollar and eliminates the relationship between the two financial markets in France.

Unlike the other European countries, the Netherlands' and Italian stock markets seem to affect the U.S. dollar using both SAC-based and local currency-based models. In addition, bidirectional causality is found among the Netherlands' stock market and the

Netherlands guilder, French franc and the Italian lira. Conversely, when the stock market is converted into SAC, an undetermined relationship exists between the Netherlands' two financial markets. Also, the French franc is not correlated with the stock market in the Netherlands. Instead, the latter causes the German mark in contemporaneous time. Finally, the stock market in Italy influences the Italian lira, Netherlands guilder, and the U.S. dollar. However, it affects the German mark instead of the Italian lira, when a local currency-based model is used. All these figures are based on a contemporaneous structure with restrictions. Overall, we find a high degree of interaction between the stock markets and exchange rates in the pre-euro period. Specifically, when the stock market indices are denominated in SAC, a strong causal relationship is found between the stock markets and exchange rates for all countries.

Similar results are found for the euro period. The Japanese yen is again the most exogenous variable, while the US dollar is the most endogenous currency among the seven countries. Stock markets in the U.K., Italy, and Germany are influenced by the British pound and euro respectively, while the Japanese yen affects stock markets in the Netherlands and France. Conversely, the Japanese stock market influences the euro. The two markets in Japan, France, and the Netherlands are correlated but causal flow is not determined. Interestingly, no contemporaneous correlation is found between the stock markets and exchange rates in the US. According to the results of local currency-based models, no contemporaneous relationship exists between the two financial markets in the US, the U.K., Germany, France, or Italy. Unidirectional causality exists from Japanese and Netherlands' stock market to the euro. Moreover, the Japanese stock market also affects the US dollar.

Overall results confirm the interconnections of stock markets and foreign currency markets. However, the SAC-based model and the local currency-based model have different contemporaneous casual structure across countries. SAC-based models are more consistent and reveal the correlation of the two markets at least within a country. In addition, these results are consistent with the OLS and time series results.

### 4.4 Innovation Accounting Results

Based on the directed graphs given in Appendix B and Bernanke ordering as estimated and programmed in RATS (Doan, 1992), the decomposition for error variance of each country is calculated and shown in Table 12 for the period from 1973 to 1998.[18] The table provides the decomposition of 0-, 1-, 12-, 24- and 35-day ahead forecast error variances of stock market indexes and all seven exchange rates of SAC-based models into fractions that are attributable to shocks in each of the seven countries. Most of the stock markets are highly exogenous given the fact that their innovations account about 95-100% of their own variance in both long-run and short-run horizons. Stock markets are 100% exogenous at time 0 or contemporaneous time in Japan, US, Germany and Italy, and only in long-run they are influenced by innovations of exchange rates by about

[18] Note that only the results of SAC-based models are reported in this thesis. Tables based on local currency-based models are available upon request from the author.

10%. The Japanese yen, under all the scenarios, is the most exogenous with 95-100% of its variance influenced by its own innovations. The stock market in the US accounts for about 2-3% of the variations in the US dollar, while the US dollar accounts for less than 1% of the variations of the US stock market. In long run, the Netherlands guilder and the Italian lira account for 2-3% and 1-2% of the variations in US stock market respectively. Interestingly, the stock market in the U.K. is less exogenous in contemporaneous time (95%) than in the 35-day period (98%). About 2-3% of its variations are due to the British pound and the German mark. Consequently, only a very small percentage of innovations in exchange rates account for German stock market variations, leaving 97-100% due to innovations in the stock market itself. About 1% of variance in the German mark, 1-2% of variance in the US dollar and 0.5-2% of variance in the French franc is explained by the innovations in German stock market, and 2-3% of variance in USD, 1-2% of variance in the German mark and 14-17% of variance in the French franc are explained by innovations in the French stock market. Up to 2-7% of the variance in the latter series is explained by innovations in the respective currency (French franc). The rest of the variance is due to innovations in its own index prices (93-96%). This indicates that in France, the stock market highly affects the foreign currency markets. Results for the Netherlands are very different from the rest of the countries. Given the fact that only about 60-80% of the variations in the stock market is explained by current shocks in its own price indices, stock markets in the Netherlands can be referred to as the least exogenous among all the seven countries in this study. It is greatly influenced by the respective exchange rate (guilder) which accounts for 4-27% of the variations in stock markets. In addition, the Japanese yen, British pound, German mark, Italian lira, and French franc together account for 10-17% of the stock market uncertainty in the Netherlands. Conversely, it influences exchange rates by very small percentage. In long-run, it affects the French franc (1-2%) and the Italian lira (6-8%) with the highest percentage. The latter exchange rate is greatly influenced (13.5-15%) by the Italian stock market, which also accounts for 2-3% of the variations in the Netherlands guilder and less than 2% in the French franc. It is very exogenous (96-100% of uncertainty is due to shocks in its own price index), with only the respective currency (ITL) explaining up to 2.5% of its variations. As we have shown, most of the stock markets are exogenous, which explains most of their own variations (up to 100% at current time). It is interesting to note that within Europe, stock markets and foreign currency markets are more interactive than those of countries outside Europe (even though the percentage of the influence is not too high for some cases).

The picture is a little different in foreign currency markets where the US dollar, German mark, and the Netherlands guilder are the most endogenous, and the Japanese yen is highly exogenous. All currencies except for the US dollar are highly influenced by the shocks in the yen (up to 20%). Besides its own shocks, the US dollar is greatly influenced by the German mark (up to 37%) and, in the long-run horizon, also by the French franc (12-13%), Italian lira (13-19%) and the Netherlands guilder (7-11%). The US dollar does not explain uncertainty in any of the exchange rates by more than 1%. European currencies explain variations in other European currencies as well as the US dollar. The British pound explains about 35% of the variations in the German mark (both in the long and short periods), which in turn explains the similar percentage of the variations in the US dollar. Another highly influential currency is the Italian lira, which accounts for about 30-35% of the variations in the Netherlands guilder. In general, the currency market is more sensitive to the movements of other currencies than stock markets.

The results of local currency-based models show that most of the countries have weakly correlated or independent financial markets. Moreover, it reports less interaction between the stock markets and the exchange rates across the countries.

Table 13 contains the decomposition of error variance of each country for the period from 1999 to 2004.[19] The table provides the decomposition of 0-, 1-, 12-, 24- and 35-day ahead forecast error variances of stock market indices and five exchange rates of SAC-based models into fractions that are attributable to shocks in each of the seven countries. The results are similar to the ones for the pre-euro period. The stock market shocks account for 94-100% of their own variance and only in a few cases, the stock markets influence exchange rates. For instance, in long-run the U.S. stock market influences U.S. dollar and euro by about 1.5-4.14% and 2-8% respectively. British pound and Japanese yen influence U.K. stock market (4.5-5.5% and 2-3% respectively). The most influenced stock market is the Italian stock market where euro accounts for 6.5-6.9% of the uncertainty in stock market. Overall, the yen has at least 1% influence on all the stock markets. In terms of currencies, the yen is again the most exogenous

[19] In the euro period (January 1999-November 2004) German mark, French franc, Italian lira and Netherlands guilder are substituted by euro, and thus there are only 5 series per each scenario. Innovation accounting is applied to first-differenced VAR as there was no cointegration among the series.

exchange rate among all, accounting for 1-4% of variance in the U.S. dollar, 33-34% in the British pound and 21-27% in the euro. On the contrary, the U.S. dollar is influenced more by the pound (37-39%) and the euro (54-60%) than by its own shocks.

Overall, the Japanese yen in all time periods and for all scenarios is found to be exogenous and the common source of innovations that are later transformed into other countries' stock markets or foreign currency markets. Stock markets and exchange rates are found to be correlated when stock market indices are denominated in SAC. However, unlike previous studies, in this study stock markets seem to explain more of the exchange rate uncertainty than vice versa. These results are consistent with the results based on the DAG, OLS regression and time series methods. Earlier, OLS regression results showed a negative significant exposure estimate of stock markets, which can be related to the results of innovation accounting techniques. Consequently, stock markets seem to influence the exchange rates in the same direction. Therefore, an increase in stock market values leads to the appreciation of the local currency because of the increase of investment inflow. Many investors, informed about the favorable stock market conditions in the $i^{th}$ country, exchange their local currency for the $i^{th}$ country's currency, thus boosting the exchange rate of their local currency for the $i^{th}$ country's currency. This phenomenon is clearly shown when stock market indices are converted into SAC or when the exchange rate risk in stock market returns is greatly minimized.

# CHAPTER V

# SUMMARY, CONCLUSIONS AND IMPLICATIONS FOR FUTURE RESEARCH

The analyses of models using OLS, time series, DAG, and innovation accounting techniques underline the importance of common denomination of both right-hand-side and left-hand-side variables. Moreover, the application of the SAC as a common denominator eliminates the problem associated with the double exchange rate risk included in both sides of the equation. All the analyzing methods show that SAC-based models yield consistent, significant, and more robust results compared to the local currency-based models. This fact can generate new opportunities for multinational corporations and investors to minimize their exchange rate risk exposure by combining certain proportions of currencies. Future research and studies are needed in order to be able to apply this concept to the developing countries with the objective to minimize their exposure to exchange rate risk.

## 5.1 Summary

The relationship between the stock markets and the exchange rates is an important and practical issue that would continue to attract many researchers attention. Many researchers study this issue with some differences than the prior studies, thus investigating the relationship between the two financial statements from another aspect. Minimizing the exchange rate risk and denominating both stock market indices and the exchange rates in the same base currency enables to study the issue from the global aspect

This study has investigated the relationship between stock markets and exchange rates for January 1, 1973 to November 19, 2004, using daily data for Japan, U.S., U.K., Germany, France, the Netherlands, and Italy. The two sub-periods are used to separate the periods before and after the euro creation: the pre-euro period (January 1973 to December 1998) and the euro period (January 1999 to November 2004). Consistent to the methodology used by many previous studies on correlation of the stock and foreign exchange markets, OLS regression analyses have been conducted. We attempted to determine the exchange rate exposure coefficients by regressing the stock price indices on changes in exchange rates. Unlike the prior studies that used stock market prices in local currency and exchange rates denominated in another base currency (such as U.S. dollar, other local currencies, or more the recently used trade-weighted exchange rate index), stable aggregate currency (SAC) was used in this study to mitigate the exchange rate risk in both stock markets and foreign currency markets. For the purpose of comparison, all the analyses have been conducted using both stock price indexes in local currencies and SAC. Also, not many studies have considered the effects of other exchange rates on a particular stock market. This study gives a clear picture of the relationship of stock markets and seven exchange rates, in addition to models with two variables.

The OLS results indicate the models in which both stock markets and exchange rates denominated in the same basket of currency (in this case SAC) outperform the models where stock markets are denominated in local currency and the exchange rates in SAC. For all sample periods, the contemporaneous relationship between stock market indices and respective exchange rates are significantly negative and yield $R^2$ that are at least a few times higher for SAC-based models relative to the local currency-based models. These results are systematic and consistent for each country. On the other hand, the application of monthly data alters the consistency of the results because both stock markets and foreign exchange markets are volatile on a daily basis. Thus, high volatility is smoothed out with monthly data, leaving relatively stable data for both markets, while not yielding the actual results. As a result, further analyses are conducted using daily data.

Besides the OLS regression, time series models along with the directed graphs are employed to illustrate the long-run relationship, as well as the graphical representation of causal flows between the stock markets and the exchange rates for each of the seven countries. Correlation coefficients and F-statistics are reported for the models with only one control variable (i.e. respective exchange rates). The findings are consistent to the OLS results which shows that stock markets and exchange rates are correlated with each other in both time periods. Moreover, the SAC-based model yields a higher negative correlation coefficient between the stock markets and the respective exchange rates than the local currency-based models.

Directed graphs indicate that the Japanese yen is very exogenous and is the primary innovation transformer in foreign currency markets. The U.S. dollar, on the other hand, is influenced by the yen, the pound, and the mark/euro[20]. In the pre-euro period, local currency-based models, consistent with prior studies, fail to find a systematic causal relationship between the stock markets and the respective exchange rates. Conversely, SAC-based models for all seven countries yield systematic results showing that stock markets and respective exchange rates are strongly interconnected to each other, but that the direction of the causal flows differ for each country. The euro-period provides a clearer picture of the causal relationship between the two financial markets. Consistent with the pre-euro period results, local currency-based models show no causal relationship between the stock markets and respective exchange rates. On the other hand, a strong causal relationship is detected for all countries using SAC-based models. Overall, graphs provide systematic results on causal relationship between the stock markets and the exchange rates. Both the OLS results and directed graphs provide evidence of a strong causal relationship in all periods and for all countries under the SAC-based models and the opposite results for local currency-based models.

The decomposition of forecast error variance provides the causal relationship in percentage terms. Using decomposition of forecast error variance for each country, we find that almost all stock markets are influenced by the exchange rates with a very low percentage (1-10% together) under the SAC-based model. Conversely, stock markets are independent from or weakly caused by the exchange rates under the local currency-based model. The later model provides the evidence that both financial markets are

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[20] In the pre-euro period, the mark influences the US dollar, and in the euro period the euro is substituted for the mark, the frank, the guilder, and the lira.

independent from each other or interrelated to each other with less than 1% in both periods. SAC-based models, however, show that both financial markets are correlated with varying degree depending on the country. For example, in the pre-euro period, the two financial markets for France, Italy and Netherlands exhibit the highest correlation, having greater effect on each other, than those for other countries. Smaller correlation is found between exchange rates and the stock markets in the euro period. All three methods yield consistent results stating that there is a causal relationship between the stock markets and exchange rates and this is accurately shown using the SAC-based models.

## 5.2 Conclusions

Overall, local currency-based models support the fact that stock markets and exchange rates are independent markets and neither of these can be used to predict the movements of the other. On the contrary, it can be concluded that SAC-based models provide evidence that the exchange rates do affect the stock markets but they account only for a small percentage of the stock market uncertainty. Conversely, the opposite causal flow has a relatively higher percentage indicating that foreign currency markets are relatively more influenced by stock markets.

## 5.3. Implications for Future Research

Many studies that examined the effects of the exchange rate variations on the stock market movements used developed countries as sample data. Consistently, in this study developed countries also have been applied to investigate the relationship between the exchange rates and the stock markets of those countries. We showed that SAC can be employed to greatly minimize the exchange rate fluctuations for both the foreign currency and the stock market. Because the emerging countries have highly volatile financial markets due to economic instability, it will be useful and practical to study how the exchange rates and stock markets of the emerging countries behave in the world market. Thus, one might explore the interconnection between the stock markets and foreign currency markets in emerging countries and developed countries by using SAC. The results might contain useful information for investors and businesses of both countries for future investment or business decisions.

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# APPENDIX A

## ABBREVIATIONS

### Stock market indexes for each of the seven countries

Nikkei – Nikkei 225 Average Composite Index (Japan)
SP - S&P 500 Composite Index (U.S.)
FTSE - FTSE 30 Ordinary Index (U.K.)
DAX - DAX 30 Performance Index (Germany)
DSFRA - DS Total Market Index (France)
AEX - AEX 30 Ordinary Index (Netherlands)
DSITL - DS Total Market Index (Italy)

### Exchange rates for each of the seven countries, 1973-1998 (the pre-euro period)

JPY – Japanese Yen
USD – U.S. Dollar
GBP – British Pound
DEM – German Mark
FRF – French Franc
ANG - Netherlands Guilder
ITL – Italian Lira

### Exchange rates for each of the seven countries, 1999-2004 (the euro period)

JPY – Japanese Yen
USD – U.S. Dollar
GBP – British Pound
EUR – Euro

### Technical terms

IMF- International Monetary Fund
SAC – Stable Aggregate Currency
SDR – Special Drawing Rights
OLS – Ordinary Least Squares
ECM- Error Correction Model
VAR – Vector Autoregression
DAG – Directed Acyclic Graphs

## APPENDIX B

## DIRECTED GRAPHS

Figures 1-7.2 represent the contemporaneous causal relationship between stock market and foreign currency market for each seven countries both with SAC and local currency models, 1973-1998. Few restrictions are placed to show that Japanese financial markets cannot be affected by either European or U.S. markets at contemporaneous time. Similarly, U.S. cannot influence Europe as well. PC algorithm is used at a 5% significance level.

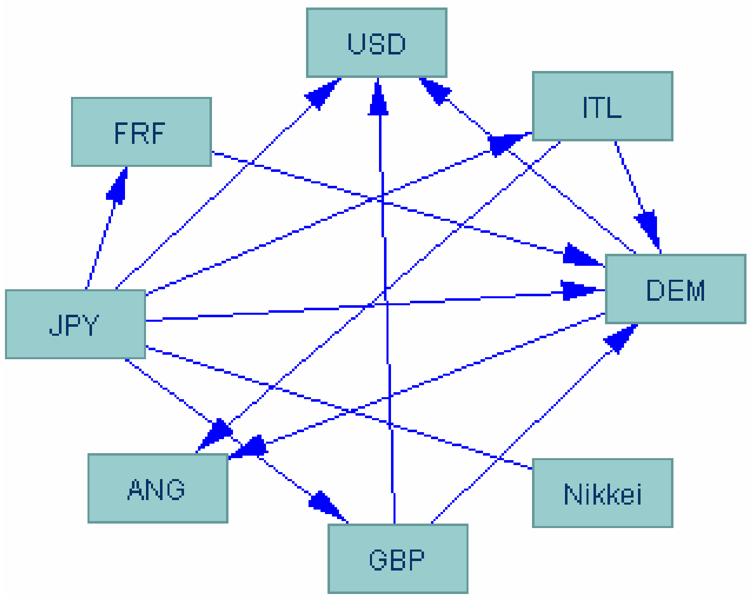


**Figure 1. Japanese stock market and the exchange rates (SAC-based and local currency-based, 1973-1998)[21]**

[21] All abbreviations and acronyms are provided in Appendix A.

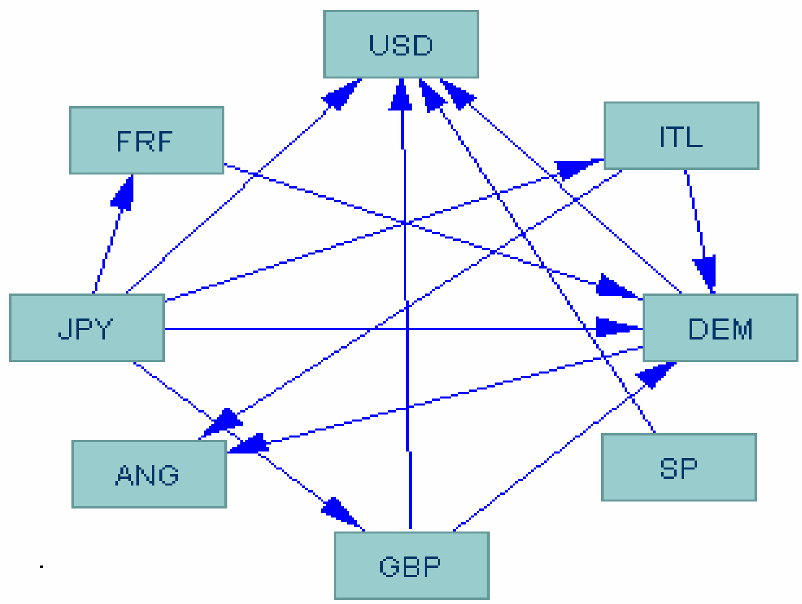


**Figure 2.1. The U.S. stock market and the exchange rates (SAC-based, 1973-1998)**

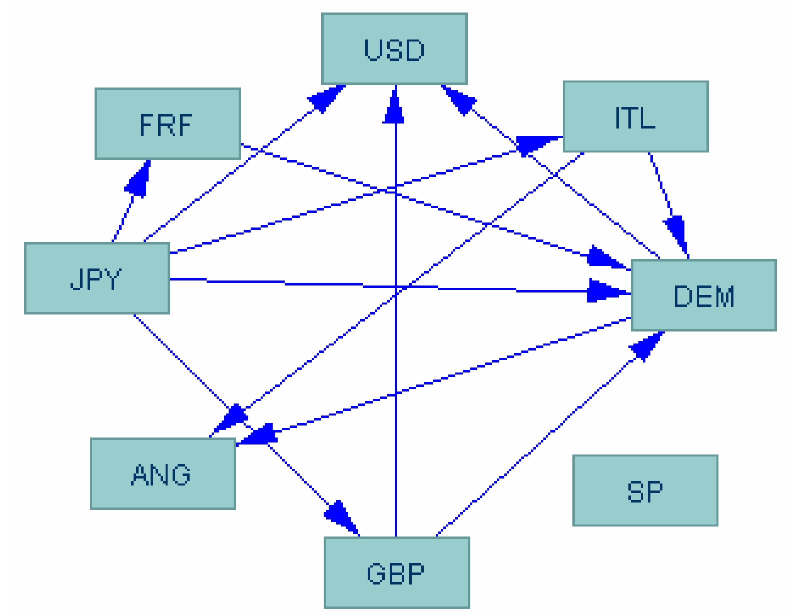


**Figure 2.2. The US stock market and the exchange rates (local currency-based, 1973-1998)**[22]

[22] All abbreviations and acronyms are provided in Appendix A.

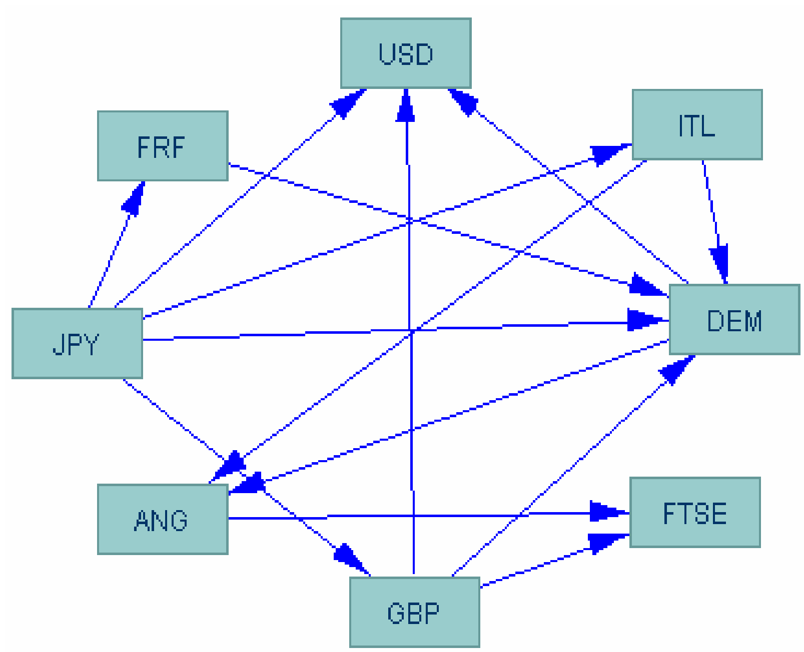


**Figure 3.1. The U.K. stock market and the exchange rates (SAC-based, 1973–1998)**

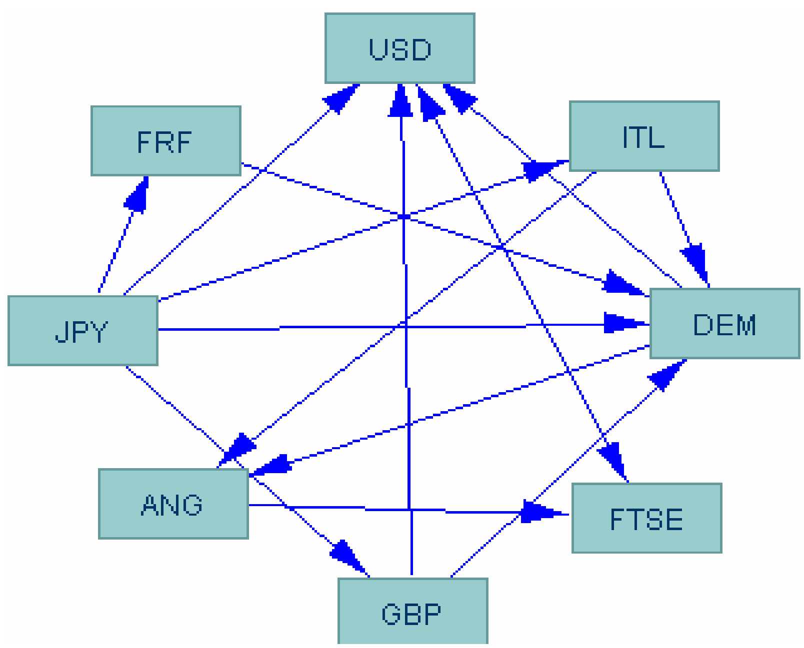


**Figure 3.2. The U.K. stock market and the exchange rates (local currency-based, 1973-1998)**[23]

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[23] All abbreviations and acronyms are provided in Appendix A.

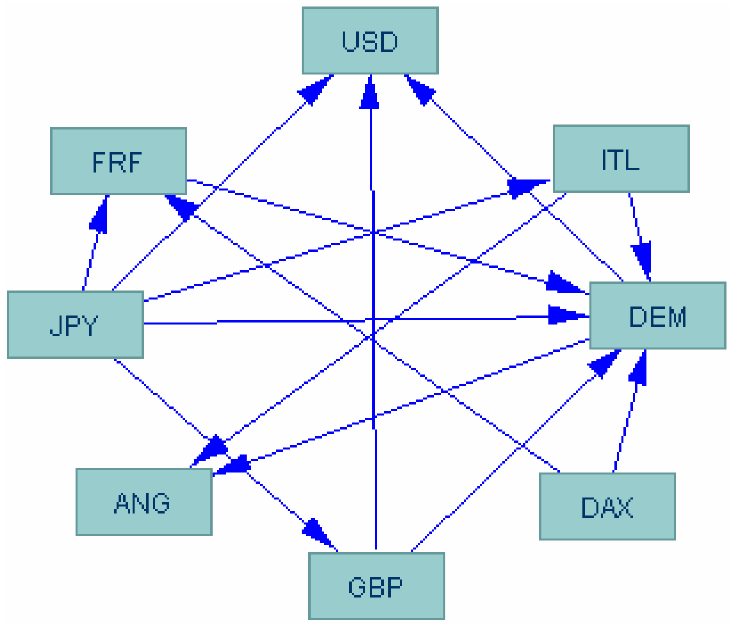


**Figure 4.1. German stock market and the exchange rates (SAC-based, 1973-1998)**

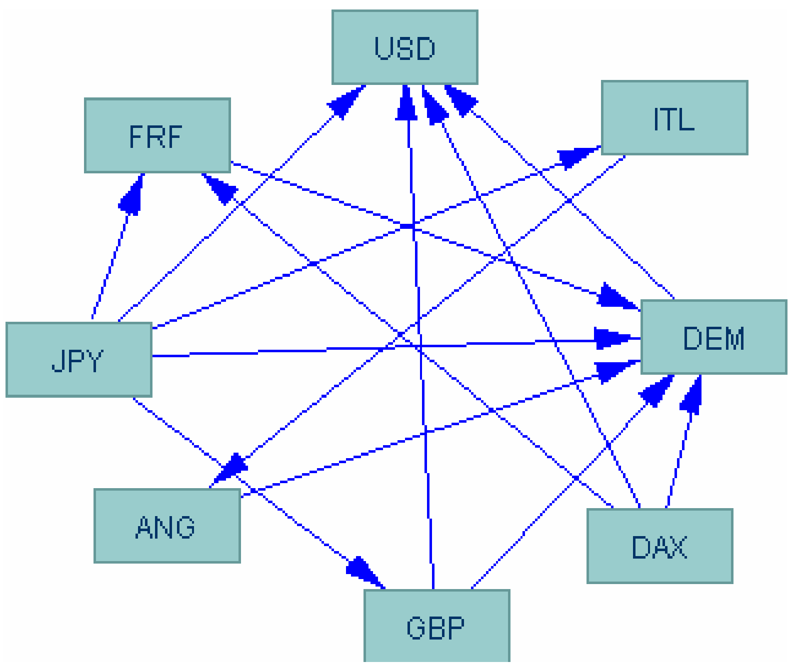


**Figure 4.2. German stock market and the exchange rates (local currency-based, 1973-1998)**[24]

[24] All abbreviations and acronyms are provided in Appendix A.

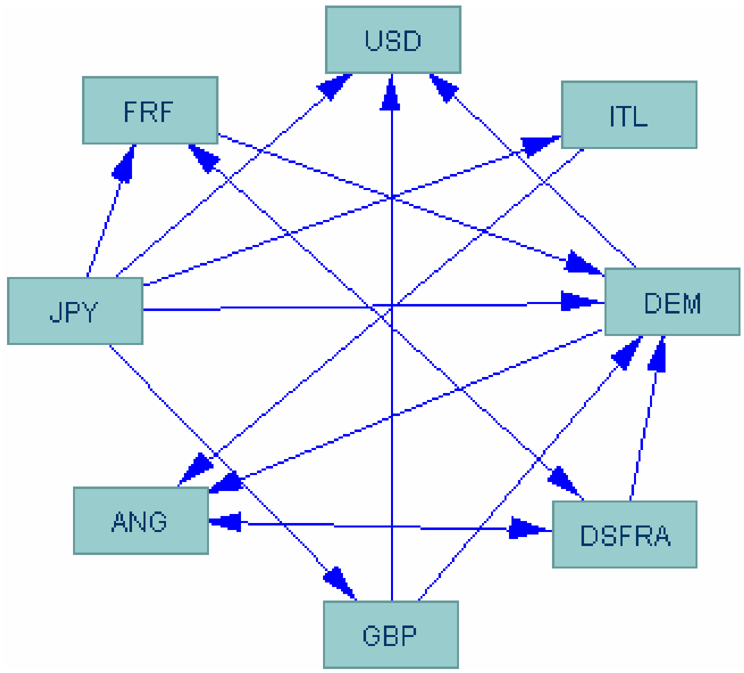


**Figure 5.1. French stock market and the exchange rates (SAC-based, 1973-1998)**

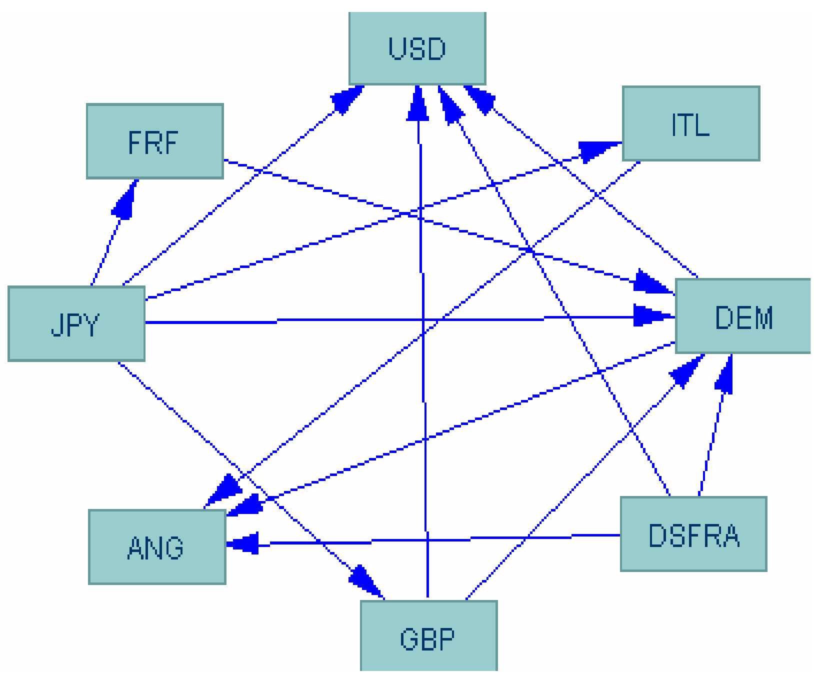


**Figure 5.2. French stock market and the exchange rates (local currency-based, 1973-1998)**[25]

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[25] All abbreviations and acronyms are provided in Appendix A.

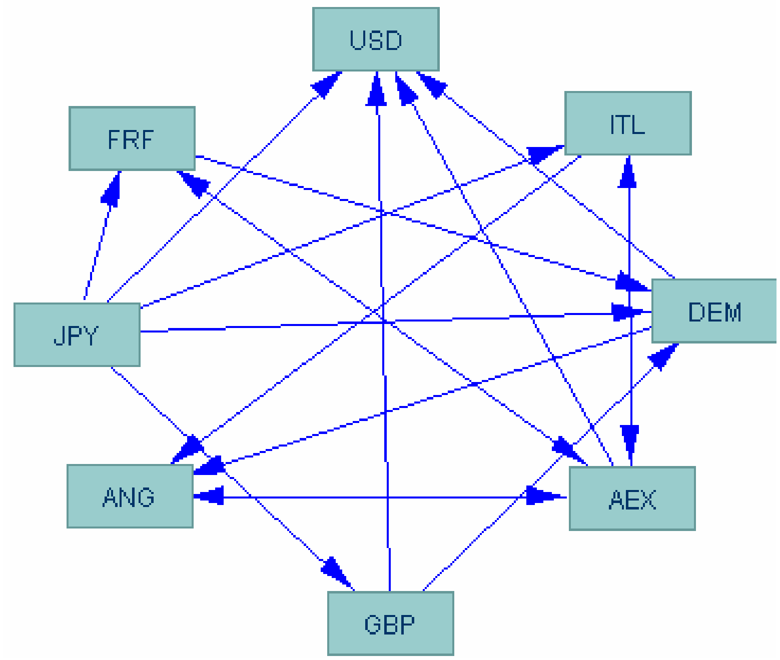


**Figure 6.1. The Netherlands stock market and the exchange rates (SAC-based, 1973-1998)**

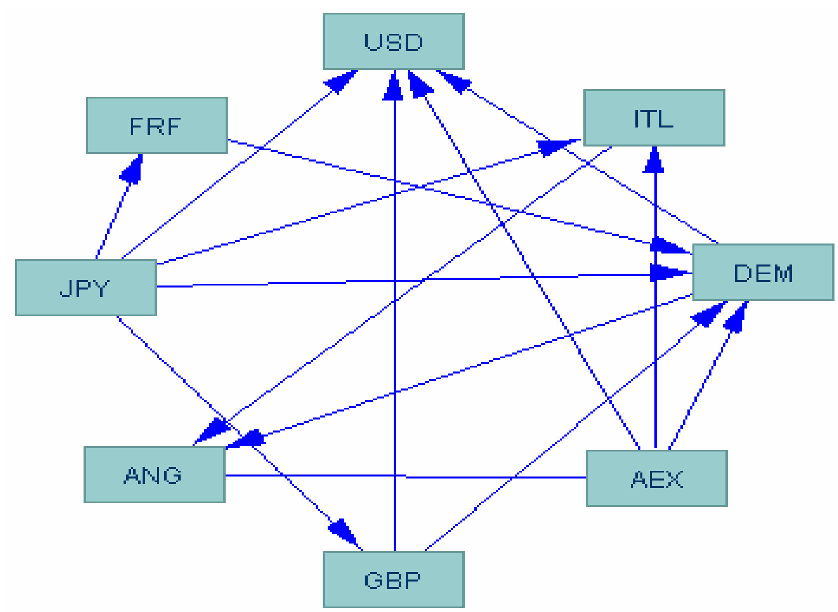


**Figure 6.2. The Netherlands stock market and the exchange rates (local currency-based, 1973-1998)**[26]

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[26] All abbreviations and acronyms are provided in Appendix A.

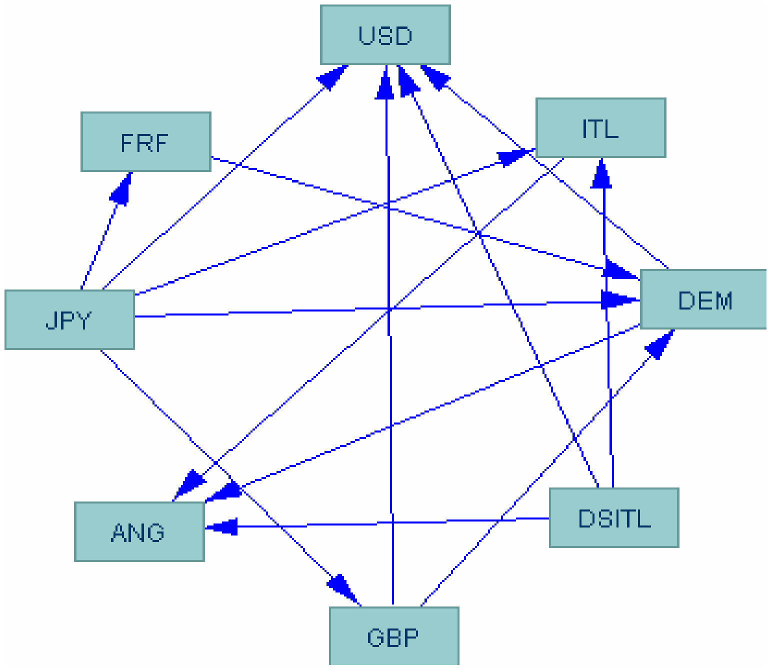


**Figure 7.1. Italian stock market and the exchange rates (SAC-based, 1973-1998)**

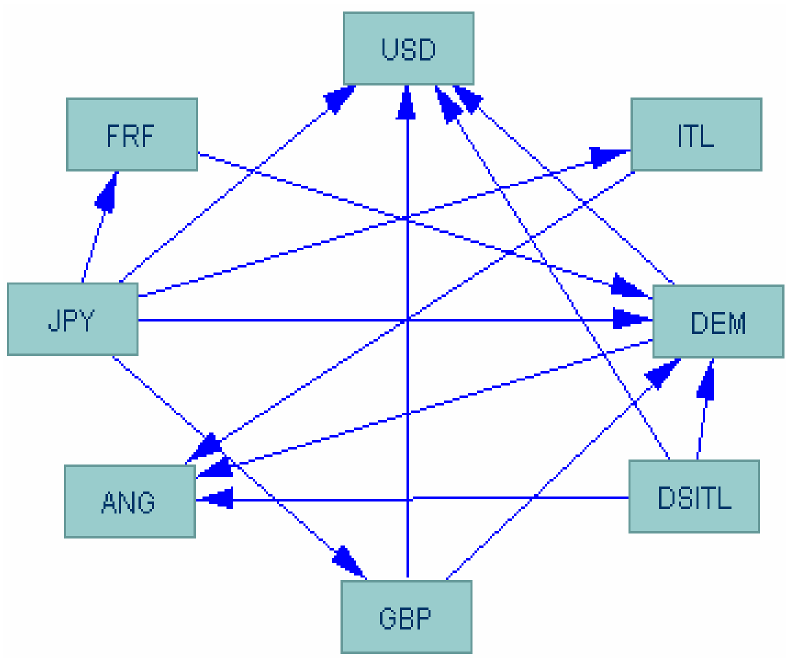


**Figure 7.2. Italian stock market and the exchange rates (local currency-based, 1973-1998)[27]**

[27] All abbreviations and acronyms are provided in Appendix A.

Figures 8.1-14.2 represent the contemporaneous causal relationship between stock market and foreign currency market for each seven countries with both SAC and local currency models, 1999-2004. Few restrictions are placed to show that Japanese financial markets cannot be affected by either European or U.S. markets at contemporaneous time. Similarly, U.S. markets cannot influence Europe European markets at current time as well (however, U.S. markets open an hour before the European markets close). PC algorithm is used at a 5% significance level. Important to notice that in the euro period, most of the European currencies are substituted by the euro.

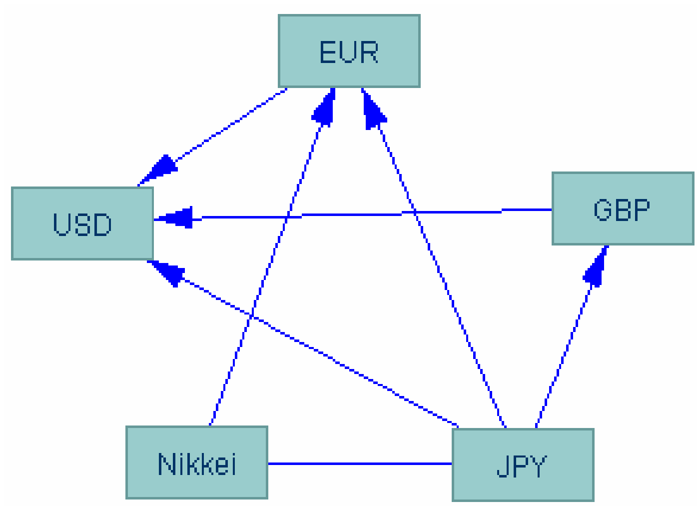


**Figure 8.1. Japanese stock market and the exchange rates (SAC-based, 1999-2004)**

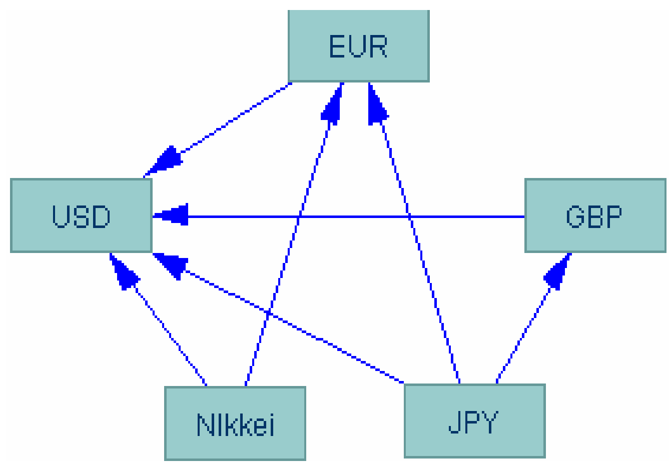


**Figure 8.2. Japanese stock market and the exchange rates (local currency-based, 1999-2004)**[28]

[28] All abbreviations and acronyms are provided in Appendix A.

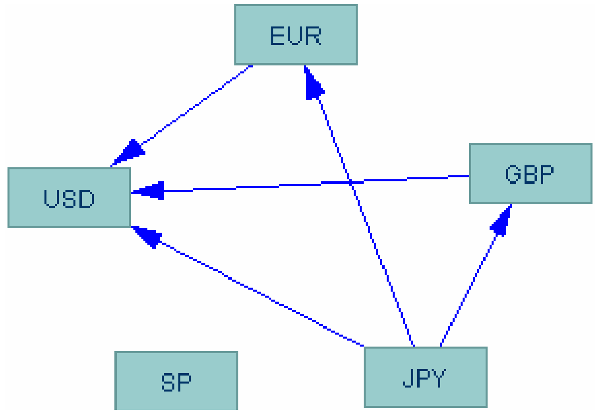


**Figure 9. The U.S. stock market and the exchange rates (SAC-based and local currency-based, 1999-2004)**

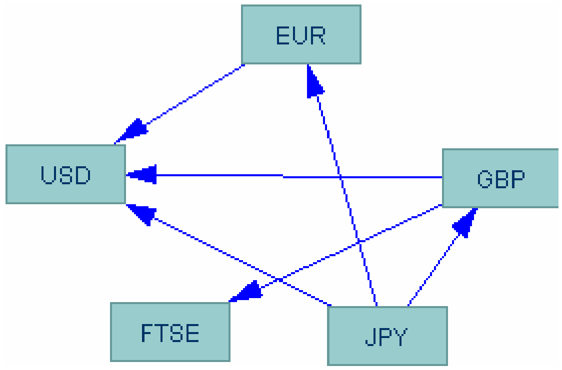


**Figure 10.1. The U.K. stock market and the exchange rates (SAC-based, 1999-2004)**

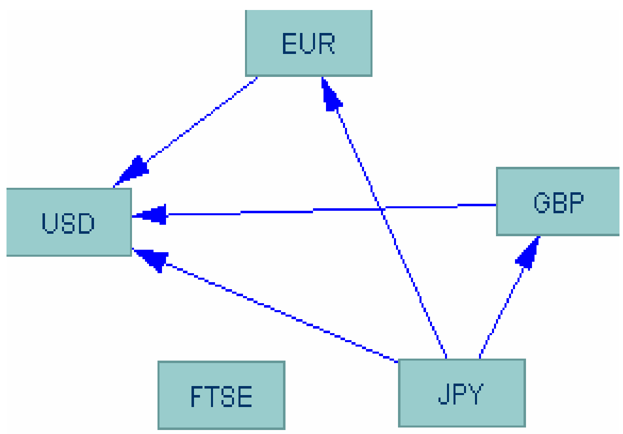


**Figure 10.2. The U.K. stock market and the exchange rates (local currency-based, 1999-2004)**[29]

29 All abbreviations and acronyms are provided in Appendix A.

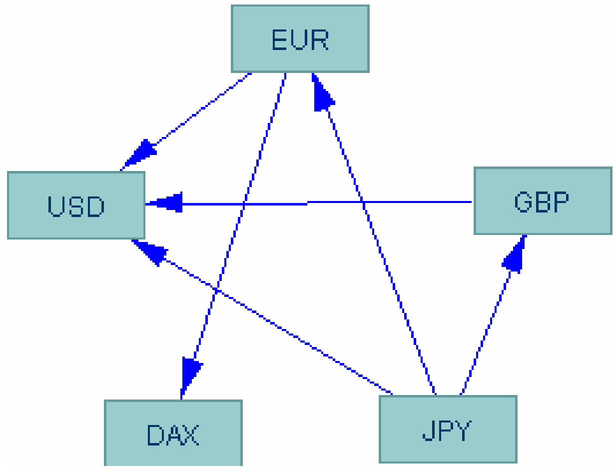


**Figure 11.1. German stock market and the exchange rates (SAC-based, 1999-2004)**

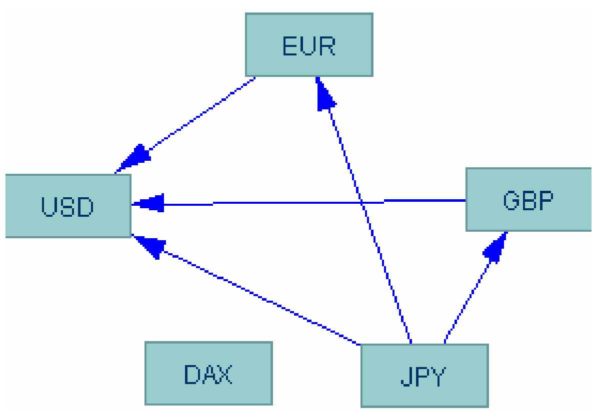


**Figure 11.2. German stock market and the exchange rates (local currency-based, 1999-2004)[30]**

[30] All abbreviations and acronyms are provided in Appendix A.

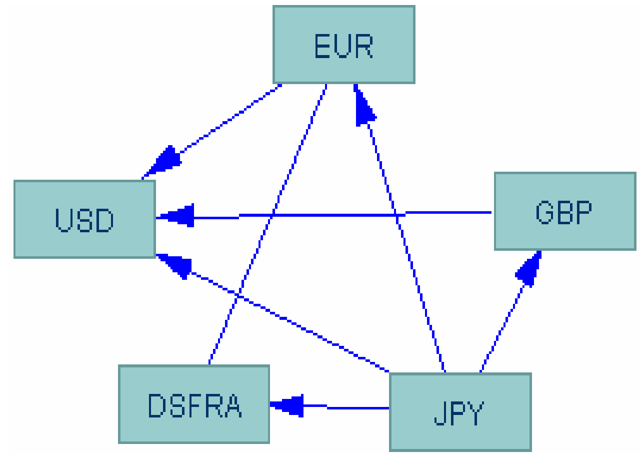


**Figure 12.1. French stock market and the exchange rates (SAC-based, 1999-2004)**[31]

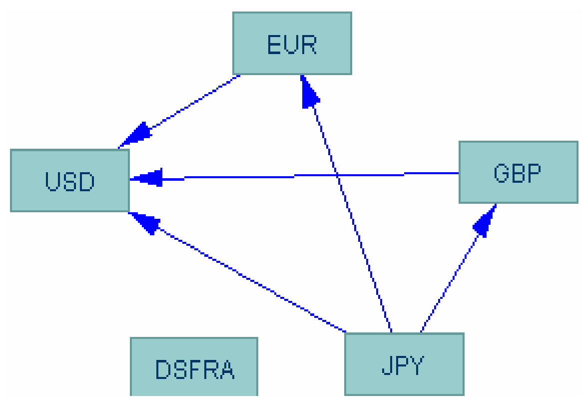


**Figure 12.2. French stock market and the exchange rates (local currency-based, 1999-2004)**

[31] All abbreviations and acronyms are provided in Appendix A.

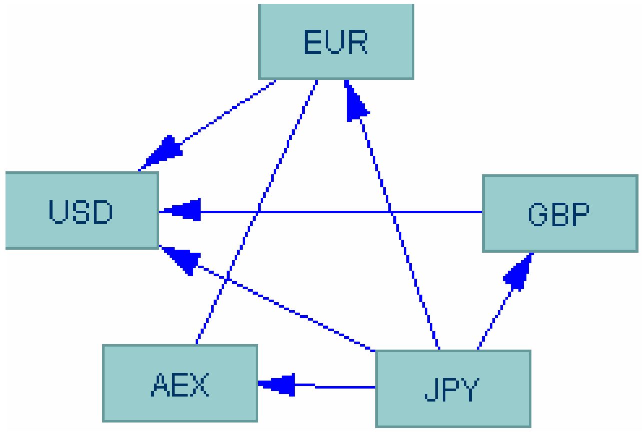


**Figure 13.1. The Netherlands stock market and the exchange rates (SAC-based, 1999-2004)**

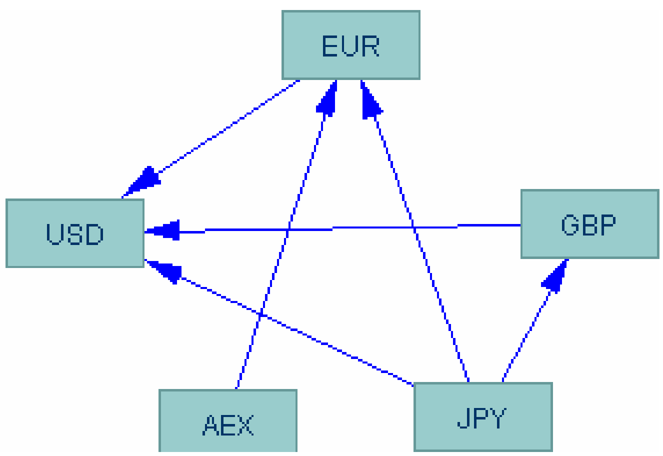


**Figure 13.2. The Netherlands stock market and the exchange rates (Local currency-based, 1999-2004)**[32]

[32] All abbreviations and acronyms are provided in Appendix A.

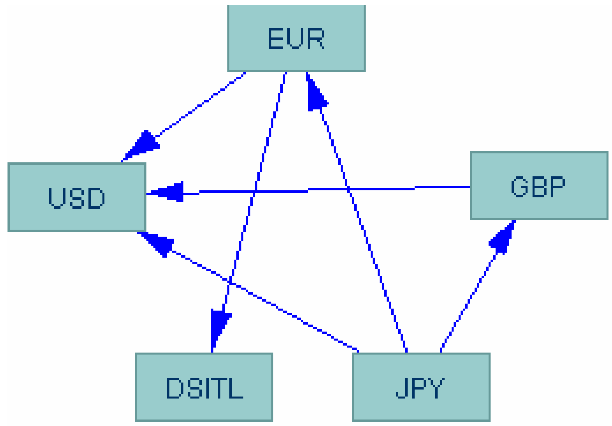


**Figure 14.1. Italian stock market and the exchange rates (SAC-based, 1999-2004)**

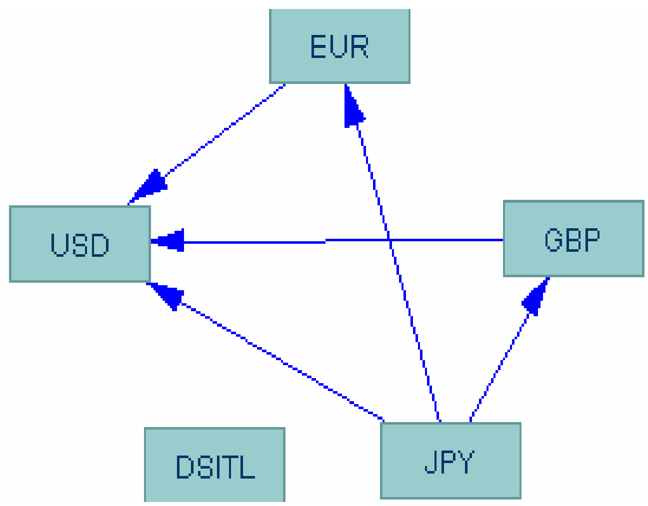


**Figure 14.2. Italian stock market and the exchange rates (local currency -based, 1999-2004)[33]**

[33] All abbreviations and acronyms are provided in Appendix A.

# APPENDIX C

## TABLES

**Table 1.1. Dickey-Fuller Test of Stationarity for Stock Indices and the Exchange Rates, 1973-1998[34]**

| Series | Number of Differences | DF test |
|---|---|---|
| Nikkei | 1 | -79.86 |
| JPY | 1 | -81.05 |
| SP | 1 | -74.40 |
| USD | 1 | -67.13 |
| FTSE | 1 | -70.20 |
| GBP | 1 | -86.49 |
| DAX | 1 | -82.15 |
| DEM | 1 | -106.08 |
| DSFRA | 1 | -74.85 |
| FRF | 1 | -101.20 |
| AEX | 1 | -90.13 |
| ANG | 1 | -119.22 |
| DSITL | 1 | -74.71 |
| ITL | 1 | -106.97 |

Note*:* Only values that are stationary at a 5% significance level are reported.

**Table 1.2. Dickey-Fuller Test of Stationarity for Stock Indices and the Exchange Rates, 1999-2004**

| Series | Number of Differences | DF test |
|---|---|---|
| Nikkei | 1 | -39.76 |
| JPY | 1 | -38.92 |
| SP | 1 | -37.99 |
| USD | 1 | -40.46 |
| FTSE | 1 | -40.17 |
| GBP | 1 | -37.71 |
| DAX | 1 | -39.39 |
| DSFRA | 1 | -40.34 |
| AEX | 1 | -41.73 |
| DSITL | 1 | -41.10 |
| EUR | 1 | -40.47 |

Note*:* German mark, French franc, Italian lira and the Netherlands' guilder has been substituted by euro. Only values that are stationary at a 5% significance level are reported.

[34] All abbreviations and acronyms are provided in Appendix A.

**Table 2.1. Loss Metrics of Schwartz-Loss and Hannan Quinn for Stock Markets and the Exchange Rates, 1973-1998[35]**

| | Local Currency-Based Model | | | | SAC-Based Model | | | |
|---|---|---|---|---|---|---|---|---|
| Country | Lag | SL* | Lag | M* | Lag | SL | Lag | M |
| Japan | 3 | -89.67 | 4 | -89.83 | 3 | -89.67 | 4 | -89.83 |
| U.S. | 3 | -89.97 | 4 | -90.13 | 3 | -89.97 | 4 | -90.13 |
| U.K. | 3 | -89.90 | 4 | -90.06 | 3 | -89.90 | 4 | -90.06 |
| Germany | 3 | -89.73 | 4 | -89.89 | 3 | -89.73 | 4 | -89.89 |
| France | 3 | -89.75 | 4 | -89.91 | 3 | -89.75 | 4 | -89.91 |
| Netherlands | 3 | -89.76 | 4 | -89.92 | 3 | -89.76 | 4 | -89.92 |
| Italy | 3 | -89.31 | 4 | -89.47 | 3 | -89.31 | 4 | -89.47 |

Note: * SL means Schwartz-Loss and M means Hannan Quinn. The values of Schwartz Loss and Hannan Quinn's M on lags of 0-10 are calculated to determine the number of lags that will be used further in the paper. This table gives only the lags representing the minimum values for both measures. For some countries, we get different lags based on the two measures. In such cases, we use both of them if that changes the further analyses.

**Table 2.2. Loss Metrics of Schwartz-Loss and Hannan Quinn for Stock Markets and the Exchange Rates, 1999-2004**

| | Local Currency-Based Model | | | | SAC-Based Model | | | |
|---|---|---|---|---|---|---|---|---|
| Country | Lag | SL | Lag | M | Lag | SL | Lag | M |
| Japan | 1 | -57.53 | 1 | -57.59 | 1 | -57.53 | 1 | -57.59 |
| U.S. | 1 | -57.83 | 1 | -57.90 | 1 | -57.83 | 1 | -57.90 |
| U.K. | 1 | -58.02 | 1 | -58.08 | 1 | -58.02 | 1 | -58.08 |
| Germany | 1 | -57.23 | 1 | -57.30 | 1 | -57.23 | 1 | -57.30 |
| France | 1 | -57.61 | 1 | -57.68 | 1 | -57.61 | 1 | -57.68 |
| Netherlands | 1 | -57.38 | 1 | -57.45 | 1 | -57.38 | 1 | -57.45 |
| Italy | 1 | -57.83 | 1 | -57.90 | 1 | -57.83 | 1 | -57.90 |

Note: * SL means Schwartz-Loss and M means Hannan Quinn. The values of Schwartz Loss and Hannan Quinn's M on lags of 0-10 are calculated to determine the number of lags that will be used further in the paper. This table gives only the lags representing the minimum values for both measures. For some countries, we get different lags based on the two measures. In such cases, we use both of them if that changes the further analyses.

[35] All abbreviations and acronyms are provided in Appendix A.

**Table 3.1. Loss Metrics of Schwartz-Loss and Hannan Quinn for Stock Markets and the Respective Exchange Rates, 1973-1998**[36]

| | Local Currency-Based Model | | | | SAC-Based Model | | | |
|---|---|---|---|---|---|---|---|---|
| Country | Lag | SL* | Lag | M* | Lag | SL | Lag | M |
| Japan | 1 | -19.71 | 3 | -19.71 | 1 | -19.71 | 3 | -19.71 |
| U.S. | 2 | -20.46 | 2 | -20.47 | 2 | -20.46 | 2 | -20.47 |
| U.K. | 2 | -20.25 | 2 | -20.26 | 2 | -20.25 | 2 | -20.26 |
| Germany | 3 | -20.10 | 3 | -20.11 | 3 | -20.10 | 3 | -20.11 |
| France | 2 | -20.24 | 3 | -20.25 | 2 | -20.24 | 3 | -20.25 |
| Netherlands | 4 | -19.53 | 5 | -19.54 | 4 | -19.53 | 5 | -19.54 |
| Italy | 3 | -19.00 | 5 | -19.01 | 3 | -19.00 | 5 | -19.01 |

Note: * SL means Schwartz-Loss and M means Hannan Quinn. The values of Schwartz Loss and Hannan Quinn's M on lags of 0-10 are calculated to determine the number of lags that will be used further in the paper. This table gives only the lags representing the minimum values for both measures. For some countries, we get different lags based on the two measures. In such cases, we use both of them if that changes the further analyses.

**Table 3.2. Loss Metrics of Schwartz-Loss and Hannan Quinn for Stock Markets and the Respective Exchange Rates, 1999-2004**

| | Local Currency-Based Model | | | | SAC-Based Model | | | |
|---|---|---|---|---|---|---|---|---|
| Country | Lag | SL | Lag | M | Lag | SL | Lag | M |
| Japan | 1 | -19.23 | 1 | -19.24 | 1 | -19.23 | 1 | -19.24 |
| U.S. | 2 | -20.11 | 3 | -20.14 | 2 | -20.11 | 3 | -20.14 |
| U.K. | 1 | -20.58 | 1 | -20.59 | 1 | -20.58 | 1 | -20.59 |
| Germany | 1 | -19.13 | 2 | -19.15 | 1 | -19.13 | 2 | -19.15 |
| France | 1 | -19.49 | 2 | -19.51 | 1 | -19.49 | 2 | -19.51 |
| Netherlands | 2 | -19.28 | 2 | -19.30 | 2 | -19.28 | 2 | -19.30 |
| Italy | 1 | -19.72 | 2 | -19.74 | 1 | -19.72 | 2 | -19.74 |

Note: * SL means Schwartz-Loss and M means Hannan Quinn. The values of Schwartz Loss and Hannan Quinn's M on lags of 0-10 are calculated to determine the number of lags that will be used further in the paper. This table gives only the lags representing the minimum values for both measures. For some countries, we get different lags based on the two measures. In such cases, we use both of them if that changes the further analyses.

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[36] All abbreviations and acronyms are provided in Appendix A.

**Table 4.1. Trace Test on Cointegration of Stock Markets and the Exchange Rates, 1973-1998[37]**

| Country | r | T* | C(5%)* | r | T | C(5%) |
|---|---|---|---|---|---|---|
| Japan | ≤2 | 59.18 | 75.74 | ≤1 | 82.68 | 93.92 |
| U.S. | ≤2 | 57.45 | 75.74 | ≤1 | 71.70 | 93.92 |
| U.K. | ≤2 | 66.48 | 75.74 | ≤1 | 82.24 | 93.92 |
| Germany | ≤2 | 62.42 | 75.74 | ≤1 | 82.93 | 93.92 |
| France | ≤2 | 54.24 | 75.74 | ≤1 | 71.36 | 93.92 |
| Netherlands | ≤2 | 60.83 | 75.74 | ≤1 | 74.64 | 93.92 |
| Italy | ≤2 | 58.26 | 75.74 | ≤1 | 80.22 | 93.92 |

Note: Only the values at which decisions are made are reported. The decisions are made at a 5% significance level.

**Table 4.2. Trace Test on Cointegration of Stock Markets and the Exchange Rates, 1999-2004**

| Country | r | T* | C(5%)* | r | T | C(5%) |
|---|---|---|---|---|---|---|
| Japan | =0 | 71.75 | 75.74 | ≤1 | 41.91 | 47.21 |
| U.S. | =0 | 60.99 | 75.74 | =0 | 60.45 | 68.68 |
| U.K. | =0 | 60.46 | 75.74 | =0 | 59.92 | 68.68 |
| Germany | =0 | 61.90 | 75.74 | =0 | 62.23 | 68.68 |
| France | =0 | 64.21 | 75.74 | =0 | 63.61 | 68.68 |
| Netherlands | =0 | 61.27 | 75.74 | =0 | 60.37 | 68.68 |
| Italy | =0 | 60.20 | 75.74 | =0 | 59.64 | 68.68 |

Note: Only the values at which decisions are made are reported. The decisions are made at a 5% significance level

[37] All abbreviations and acronyms are provided in Appendix A.

**Table 5.1. Trace Test on Cointegration of Stock Markets and the Respective Exchange Rates, 1973-1998[38]**

| Country | r | T* | C(5%)* | r | T | C(5%) |
|---|---|---|---|---|---|---|
| Japan | =0 | 8.83 | 19.99 | =0 | 4.42 | 15.34 |
| U.S. | =0 | 13.20 | 19.99 | =0 | 5.25 | 15.34 |
| U.K. | ≤1 | 8.42 | 9.13 | =0 | 15.28 | 15.34 |
| Germany | ≤1 | 3.71 | 9.13 | ≤1 | 0.47 | 3.84 |
| France | =0 | 13.59 | 19.99 | =0 | 5.15 | 15.34 |
| Netherlands | ≤1 | 10.67 | 9.13 | =0 | 12.87 | 15.34 |
| Italy | ≤1 | 8.82 | 9.13 | =0 | 14.20 | 15.34 |

Note: Only the values at which decisions are made are reported. The decisions are made at a 5% significance level

**Table 5.2. Trace Test on Cointegration of Stock Markets and the Respective Exchange Rates, 1999-2004**

| Country | r | T* | C(5%)* | r | T | C(5%) |
|---|---|---|---|---|---|---|
| Japan | ≤1 | 3.10 | 9.13 | ≤1 | 2.98 | 3.84 |
| U.S. | =0 | 9.40 | 19.99 | =0 | 9.06 | 15.34 |
| U.K. | =0 | 10.47 | 19.99 | =0 | 10.33 | 15.34 |
| Germany | =0 | 15.01 | 19.99 | =0 | 14.73 | 15.34 |
| France | =0 | 11.87 | 19.99 | =0 | 11.84 | 15.34 |
| Netherlands | =0 | 15.96 | 19.99 | ≤1 | 1.07 | 3.84 |
| Italy | =0 | 10.36 | 19.99 | =0 | 10.28 | 15.34 |

Note: Only the values at which decisions are made are reported. The decisions are made at a 5% significance level

[38] All abbreviations and acronyms are provided in Appendix A.

**Table 6.1. Test on Exclusion of Japanese Stock Market and the Exchange Rates from the Cointegration Space, 1973-1998[39]**

| Stock Price Index and Exchange Rates (Currency/SAC) | Chi-Squared test | p-value | Decision |
|---|---|---|---|
| *Local Currency-based Model* | | | |
| NIKKEI | 1.36 | 0.244 | F |
| JPY | 0.53 | 0.467 | F |
| USD | 2.03 | 0.154 | F |
| GBP | 6.78 | 0.009 | R |
| DEM | 25.62 | 0.000 | R |
| FRF | 0.99 | 0.320 | F |
| ANG | 25.42 | 0.000 | R |
| ITL | 4.71 | 0.030 | R |
| *SAC-based Model* | | | |
| NIKKEI | 1.36 | 0.244 | F |
| JPY | 0.23 | 0.632 | F |
| USD | 2.03 | 0.154 | F |
| GBP | 6.78 | 0.009 | R |
| DEM | 25.62 | 0.000 | R |
| FRF | 0.99 | 0.320 | F |
| ANG | 25.42 | 0.000 | R |
| ITL | 4.71 | 0.030 | R |

Note: Tests are on the null hypothesis that the particular series listed in the far left-hand column is not in the cointegration space. The heading "Decision" relates to the decision to reject (R) or fail to reject (F) the null hypothesis at a 5 % significance level. Under the null hypothesis, the test statistic is distributed chi-squared with one degree of freedom.

[39] All abbreviations and acronyms are provided in Appendix A.

**Table 6.2. Test on Exclusion of U.S. Stock Market and the Exchange Rates from the Cointegration Space, 1973-1998[40]**

| Stock Price Index and Exchange Rates (Currency/SAC) | Chi-Squared test | p-value | Decision |
|---|---|---|---|
| *Local Currency-based Model* | | | |
| S&P 500 | 1.16 | 0.281 | F |
| JPY | 1.58 | 0.209 | F |
| USD | 1.72 | 0.190 | F |
| GBP | 7.45 | 0.006 | R |
| DEM | 25.33 | 0.000 | R |
| FRF | 3.27 | 0.071 | F |
| ANG | 25.16 | 0.000 | R |
| ITL | 4.06 | 0.044 | R |
| *SAC-based Model* | | | |
| S&P 500 | 1.16 | 0.281 | F |
| JPY | 1.58 | 0.209 | F |
| USD | 2.04 | 0.153 | F |
| GBP | 7.45 | 0.006 | R |
| DEM | 25.33 | 0.000 | R |
| FRF | 3.27 | 0.071 | F |
| ANG | 25.16 | 0.000 | R |
| ITL | 4.06 | 0.044 | R |

Note: Tests are on the null hypothesis that the particular series listed in the far left-hand column is not in the cointegration space. The heading "Decision" relates to the decision to reject (R) or fail to reject (F) the null hypothesis at a 5 % significance level. Under the null hypothesis, the test statistic is distributed chi-squared with one degree of freedom.

[40] All abbreviations and acronyms are provided in Appendix A.

**Table 6.3. Test on Exclusion of U.K. Stock Market and the Exchange Rates from the Cointegration Space, 1973-1998[41]**

| Stock Price Index and Exchange Rates (Currency/SAC) | Chi-Squared test | p-value | Decision |
|---|---|---|---|
| *Local Currency-based Model* | | | |
| FTSE | 0.82 | 0.365 | F |
| JPY | 0.58 | 0.446 | F |
| USD | 2.28 | 0.131 | F |
| GBP | 5.9 | 0.015 | R |
| DEM | 24.73 | 0.000 | R |
| FRF | 3.02 | 0.082 | F |
| ANG | 24.41 | 0.000 | R |
| ITL | 1.82 | 0.177 | F |
| *SAC-based Model* | | | |
| FTSE | 0.82 | 0.365 | F |
| JPY | 0.58 | 0.446 | F |
| USD | 2.28 | 0.131 | F |
| GBP | 5.08 | 0.024 | R |
| DEM | 24.73 | 0.000 | R |
| FRF | 3.02 | 0.082 | F |
| ANG | 24.41 | 0.000 | R |
| ITL | 1.82 | 0.177 | F |

Note: Tests are on the null hypothesis that the particular series listed in the far left-hand column is not in the cointegration space. The heading "Decision" relates to the decision to reject (R) or fail to reject (F) the null hypothesis at a 5 % significance level. Under the null hypothesis, the test statistic is distributed chi-squared with one degree of freedom.

[41] All abbreviations and acronyms are provided in Appendix A.

**Table 6.4. Test on Exclusion of German Stock Market and the Exchange Rates from the Cointegration Space, 1973-1998**[42]

| Stock Price Index and Exchange Rates (Currency/SAC) | Chi-Squared test | p-value | Decision |
|---|---|---|---|
| *Local Currency-based Model* | | | |
| DAX | 0.83 | 0.362 | F |
| JPY | 1.71 | 0.191 | F |
| USD | 2.63 | 0.105 | F |
| GBP | 7.17 | 0.007 | R |
| DEM | 23.68 | 0.000 | R |
| FRF | 2.45 | 0.118 | F |
| ANG | 23.27 | 0.000 | R |
| ITL | 4.66 | 0.031 | R |
| *SAC-based Model* | | | |
| DAX | 0.83 | 0.362 | F |
| JPY | 1.71 | 0.191 | F |
| USD | 2.63 | 0.105 | F |
| GBP | 7.17 | 0.007 | R |
| DEM | 23.67 | 0.000 | R |
| FRF | 2.45 | 0.118 | F |
| ANG | 23.27 | 0.000 | R |
| ITL | 4.66 | 0.031 | R |

Note: Tests are on the null hypothesis that the particular series listed in the far left-hand column is not in the cointegration space. The heading "Decision" relates to the decision to reject (R) or fail to reject (F) the null hypothesis at a 5 % significance level. Under the null hypothesis, the test statistic is distributed chi-squared with one degree of freedom.

[42] All abbreviations and acronyms are provided in Appendix A.

**Table 6.5. Test on Exclusion of French Stock Market and the Exchange Rates from the Cointegration Space, 1973-1998[43]**

| Stock Price Index and Exchange Rates (Currency/SAC) | Chi-Squared test | p-value | Decision |
|---|---|---|---|
| *Local Currency-based Model* | | | |
| DSFRA | 0.92 | 0.337 | F |
| JPY | 0.72 | 0.396 | F |
| USD | 2.19 | 0.139 | F |
| GBP | 6.16 | 0.013 | R |
| DEM | 20.86 | 0.000 | R |
| FRF | 2.88 | 0.090 | F |
| ANG | 20.77 | 0.000 | R |
| ITL | 2.49 | 0.115 | F |
| *SAC-based Model* | | | |
| DSFRA | 0.92 | 0.337 | F |
| JPY | 0.72 | 0.396 | F |
| USD | 2.19 | 0.139 | F |
| GBP | 6.16 | 0.013 | R |
| DEM | 20.86 | 0.000 | R |
| FRF | 3.18 | 0.075 | F |
| ANG | 20.77 | 0.000 | R |
| ITL | 2.49 | 0.115 | F |

Note: Tests are on the null hypothesis that the particular series listed in the far left-hand column is not in the cointegration space. The heading "Decision" relates to the decision to reject (R) or fail to reject (F) the null hypothesis at a 5 % significance level. Under the null hypothesis, the test statistic is distributed chi-squared with one degree of freedom.

[43] All abbreviations and acronyms are provided in Appendix A.

**Table 6.6. Test on Exclusion of Netherlands Stock Market and the Exchange Rates from the Cointegration Space, 1973-1998[44]**

| Stock Price Index and Exchange Rates (Currency/SAC) | Chi-Squared test | p-value | Decision |
|---|---|---|---|
| *Local Currency-based Model* | | | |
| AEX | 0.47 | 0.493 | F |
| JPY | 1.27 | 0.260 | F |
| USD | 2.03 | 0.154 | F |
| GBP | 6.71 | 0.010 | R |
| DEM | 24.28 | 0.000 | R |
| FRF | 3.16 | 0.075 | F |
| ANG | 23.99 | 0.000 | R |
| ITL | 4.16 | 0.041 | R |
| *SAC-based Model* | | | |
| AEX | 0.47 | 0.493 | F |
| JPY | 1.27 | 0.260 | F |
| USD | 2.03 | 0.154 | F |
| GBP | 6.71 | 0.010 | R |
| DEM | 24.28 | 0.000 | R |
| FRF | 3.16 | 0.075 | F |
| ANG | 23.99 | 0.000 | R |
| ITL | 4.16 | 0.041 | R |

Note: Tests are on the null hypothesis that the particular series listed in the far left-hand column is not in the cointegration space. The heading "Decision" relates to the decision to reject (R) or fail to reject (F) the null hypothesis at a 5 % significance level. Under the null hypothesis, the test statistic is distributed chi-squared with one degree of freedom.

[44] All abbreviations and acronyms are provided in Appendix A.

**Table 6.7. Test on Exclusion of Italian Stock Market and the Exchange Rates from the Cointegration Space, 1973-1998**[45]

| Stock Price Index and Exchange Rates (Currency/SAC) | Chi-Squared test | p-value | Decision |
|---|---|---|---|
| *Local Currency-based Model* | | | |
| DSITL | 0.13 | 0.718 | F |
| JPY | 0.92 | 0.337 | F |
| USD | 1.44 | 0.230 | F |
| GBP | 5.49 | 0.019 | R |
| DEM | 13.98 | 0.000 | R |
| FRF | 2.99 | 0.084 | F |
| ANG | 13.94 | 0.000 | R |
| ITL | 2.69 | 0.101 | F |
| *SAC-based Model* | | | |
| DSITL | 0.13 | 0.718 | F |
| JPY | 0.92 | 0.337 | F |
| USD | 1.44 | 0.230 | F |
| GBP | 5.49 | 0.019 | R |
| DEM | 13.98 | 0.000 | R |
| FRF | 2.99 | 0.084 | F |
| ANG | 13.94 | 0.000 | R |
| ITL | 2.46 | 0.117 | F |

Note: Tests are on the null hypothesis that the particular series listed in the far left-hand column is not in the cointegration space. The heading "Decision" relates to the decision to reject (R) or fail to reject (F) the null hypothesis at a 5 % significance level. Under the null hypothesis, the test statistic is distributed chi-squared with one degree of freedom.

[45] All abbreviations and acronyms are provided in Appendix A.

**Table 7.1. Test for Weak Exogenity of Japanese Stock Market and the Exchange Rates from the Cointegration Space, 1973-1998[46]**

| Stock Price Index and Exchange Rates (Currency/SAC) | Chi-Squared test | p-value | Decision |
|---|---|---|---|
| *Local Currency-based Model* | | | |
| NIKKEI | 2.95 | 0.086 | F |
| JPY | 0.02 | 0.888 | F |
| USD | 20.16 | 0.000 | R |
| GBP | 3.64 | 0.056 | F |
| DEM | 6.34 | 0.012 | R |
| FRF | 5.79 | 0.016 | R |
| ANG | 8.09 | 0.004 | R |
| ITL | 5.76 | 0.016 | R |
| *SAC-based Model* | | | |
| NIKKEI | 2.24 | 0.134 | F |
| JPY | 0.02 | 0.888 | F |
| USD | 20.16 | 0.000 | R |
| GBP | 3.64 | 0.056 | F |
| DEM | 6.34 | 0.012 | R |
| FRF | 5.79 | 0.016 | R |
| ANG | 8.09 | 0.004 | R |
| ITL | 5.76 | 0.016 | R |

Note: Tests are on the null hypothesis that the particular series listed in the far left-hand column is weakly exogenous with respect to perturbations in the cointegrating vector. The heading "Decision" relates to the decision to reject (R) or fail to reject (F) the null hypothesis of weak exogenity at a 5% significance level. Under the null hypothesis, the test statistic is distributed chi-squared with one degree of freedom.

[46] All abbreviations and acronyms are provided in Appendix A.

**Table 7.2. Test for Weak Exogenity of U.S. Stock Market and the Exchange Rates from the Cointegration Space, 1973-1998[47]**

| Stock Price Index and Exchange Rates (Currency/SAC) | Chi-Squared test | p-value | Decision |
|---|---|---|---|
| *Local Currency-based Model* | | | |
| S&P 500 | 0.490 | 0.484 | F |
| JPY | 0.000 | 1.000 | F |
| USD | 22.100 | 0.000 | R |
| GBP | 4.180 | 0.041 | R |
| DEM | 6.440 | 0.011 | R |
| FRF | 6.450 | 0.011 | R |
| ANG | 8.160 | 0.004 | R |
| ITL | 6.610 | 0.010 | R |
| *SAC-based Model* | | | |
| S&P 500 | 3.900 | 0.048 | R |
| JPY | 0.000 | 1.000 | F |
| USD | 22.100 | 0.000 | R |
| GBP | 4.180 | 0.041 | R |
| DEM | 6.440 | 0.011 | R |
| FRF | 6.450 | 0.011 | R |
| ANG | 8.160 | 0.004 | R |
| ITL | 6.610 | 0.010 | R |

Note: Tests are on the null hypothesis that the particular series listed in the far left-hand column is weakly exogenous with respect to perturbations in the cointegrating vector. The heading “Decision” relates to the decision to reject (R) or fail to reject (F) the null hypothesis of weak exogenity at a 5% significance level. Under the null hypothesis, the test statistic is distributed chi-squared with one degree of freedom.

[47] All abbreviations and acronyms are provided in Appendix A.

**Table 7.3. Test for Weak Exogenity of U.K. Stock Market and the Exchange Rates from the Cointegration Space, 1973-1998[48]**

| Stock Price Index and Exchange Rates (Currency/SAC) | Chi-Squared test | p-value | Decision |
|---|---|---|---|
| *Local Currency-based Model* | | | |
| FTSE | 0.06 | 0.8065 | F |
| JPY | 0.12 | 0.7290 | F |
| USD | 22.26 | 0.0000 | R |
| GBP | 4.07 | 0.0437 | R |
| DEM | 6.89 | 0.0087 | R |
| FRF | 5.49 | 0.0191 | R |
| ANG | 7.38 | 0.0066 | R |
| ITL | 7.57 | 0.0059 | R |
| *SAC-based Model* | | | |
| FTSE | 0.24 | 0.624 | F |
| JPY | 0.12 | 0.729 | F |
| USD | 22.26 | 0.000 | R |
| GBP | 4.07 | 0.044 | R |
| DEM | 6.89 | 0.0087 | R |
| FRF | 5.49 | 0.0191 | R |
| ANG | 7.38 | 0.0066 | R |
| ITL | 7.57 | 0.0059 | R |

Note: Tests are on the null hypothesis that the particular series listed in the far left-hand column is weakly exogenous with respect to perturbations in the cointegrating vector. The heading "Decision" relates to the decision to reject (R) or fail to reject (F) the null hypothesis of weak exogenity at a 5% significance level. Under the null hypothesis, the test statistic is distributed chi-squared with one degree of freedom.

[48] All abbreviations and acronyms are provided in Appendix A.

**Table 7.4. Test for Weak Exogenity of German Stock Market and the Exchange Rates from the Cointegration Space, 1973-1998**[49]

| Stock Price Index and Exchange Rates (Currency/SAC) | Chi-Squared test | p-value | Decision |
|---|---|---|---|
| *Local Currency-based Model* | | | |
| DAX | 0.610 | 0.435 | F |
| JPY | 0.060 | 0.806 | F |
| USD | 19.140 | 0.000 | R |
| GBP | 4.950 | 0.026 | R |
| DEM | 7.420 | 0.006 | R |
| FRF | 4.200 | 0.040 | R |
| ANG | 7.040 | 0.008 | R |
| ITL | 8.430 | 0.004 | R |
| *SAC-based Model* | | | |
| DAX | 2.870 | 0.090 | F |
| JPY | 0.060 | 0.806 | F |
| USD | 19.140 | 0.000 | R |
| GBP | 4.950 | 0.026 | R |
| DEM | 7.420 | 0.006 | R |
| FRF | 4.200 | 0.040 | R |
| ANG | 7.040 | 0.008 | R |
| ITL | 8.430 | 0.004 | R |

Note: Tests are on the null hypothesis that the particular series listed in the far left-hand column is weakly exogenous with respect to perturbations in the cointegrating vector. The heading "Decision" relates to the decision to reject (R) or fail to reject (F) the null hypothesis of weak exogenity at a 5% significance level. Under the null hypothesis, the test statistic is distributed chi-squared with one degree of freedom.

[49] All abbreviations and acronyms are provided in Appendix A.

**Table 7.5. Test for Weak Exogenity of French Stock Market and the Exchange Rates from the Cointegration Space, 1973-1998[50]**

| Stock Price Index and Exchange Rates (Currency/SAC) | Chi-Squared test | p-value | Decision |
|---|---|---|---|
| *Local Currency-based Model* | | | |
| DSFRA | 0.27 | 0.603 | F |
| JPY | 0.03 | 0.862 | F |
| USD | 20.62 | 0.000 | R |
| GBP | 3.38 | 0.066 | F |
| DEM | 5.66 | 0.017 | R |
| FRF | 5.88 | 0.015 | R |
| ANG | 6.82 | 0.009 | R |
| ITL | 6.22 | 0.013 | R |
| *SAC-based Model* | | | |
| DSFRA | 0.11 | 0.740 | F |
| JPY | 0.03 | 0.862 | F |
| USD | 20.62 | 0.000 | R |
| GBP | 3.38 | 0.066 | F |
| DEM | 5.66 | 0.017 | R |
| FRF | 5.88 | 0.015 | R |
| ANG | 6.82 | 0.009 | R |
| ITL | 6.22 | 0.013 | R |

Note: Tests are on the null hypothesis that the particular series listed in the far left-hand column is weakly exogenous with respect to perturbations in the cointegrating vector. The heading "Decision" relates to the decision to reject (R) or fail to reject (F) the null hypothesis of weak exogenity at a 5% significance level. Under the null hypothesis, the test statistic is distributed chi-squared with one degree of freedom.

[50] All abbreviations and acronyms are provided in Appendix A.

**Table 7.6. Test for Weak Exogenity of Netherlands Stock Market and the Exchange Rates from the Cointegration Space, 1973-1998[51]**

| Stock Price Index and Exchange Rates (Currency/SAC) | Chi-Squared test | p-value | Decision |
|---|---|---|---|
| *Local Currency-based Model* | | | |
| AEX | 0.34 | 0.560 | F |
| JPY | 0.06 | 0.806 | F |
| USD | 20.96 | 0.000 | R |
| GBP | 4.68 | 0.031 | R |
| DEM | 7.06 | 0.008 | R |
| FRF | 4.93 | 0.026 | R |
| ANG | 7.44 | 0.006 | R |
| ITL | 7.68 | 0.006 | R |
| *SAC-based Model* | | | |
| AEX | 0.65 | 0.420 | F |
| JPY | 0.06 | 0.806 | F |
| USD | 20.96 | 0.000 | R |
| GBP | 4.68 | 0.031 | R |
| DEM | 7.06 | 0.008 | R |
| FRF | 4.93 | 0.026 | R |
| ANG | 7.44 | 0.006 | R |
| ITL | 7.68 | 0.006 | R |

Note: Tests are on the null hypothesis that the particular series listed in the far left-hand column is weakly exogenous with respect to perturbations in the cointegrating vector. The heading "Decision" relates to the decision to reject (R) or fail to reject (F) the null hypothesis of weak exogenity at a 5% significance level. Under the null hypothesis, the test statistic is distributed chi-squared with one degree of freedom.

[51] All abbreviations and acronyms are provided in Appendix A.

**Table 7.7. Test for Weak Exogenity of Italian Stock Market and the Exchange Rates from the Cointegration Space, 1973-1998**[52]

| Stock Price Index and Exchange Rates (Currency/SAC) | Chi-Squared test | p-value | Decision |
|---|---|---|---|
| *Local Currency-based Model* | | | |
| DSITL | 0.22 | 0.639 | F |
| JPY | 0.02 | 0.888 | F |
| USD | 13.87 | 0.000 | R |
| GBP | 2.63 | 0.105 | F |
| DEM | 3.91 | 0.048 | R |
| FRF | 5.05 | 0.025 | R |
| ANG | 6.68 | 0.010 | R |
| ITL | 5.41 | 0.020 | R |
| *SAC-based Model* | | | |
| DSITL | 2.01 | 0.156 | F |
| JPY | 0.02 | 0.888 | F |
| USD | 13.87 | 0.000 | R |
| GBP | 2.63 | 0.105 | F |
| DEM | 3.91 | 0.048 | R |
| FRF | 5.05 | 0.025 | R |
| ANG | 6.68 | 0.010 | R |
| ITL | 5.41 | 0.020 | R |

Note: Tests are on the null hypothesis that the particular series listed in the far left-hand column is weakly exogenous with respect to perturbations in the cointegrating vector. The heading "Decision" relates to the decision to reject (R) or fail to reject (F) the null hypothesis of weak exogenity at a 5% significance level. Under the null hypothesis, the test statistic is distributed chi-squared with one degree of freedom.

[52] All abbreviations and acronyms are provided in Appendix A.

**Table 8.1. Tests on Exclusion of German Stock Market and the Respective Exchange Rate from the Cointegration Space, 1973-1998[53]**

| Stock Price Index and Exchange Rates (Currency/SAC) | Chi-Squared test | p-value | Decision |
|---|---|---|---|
| *Local Currency-based Model* | | | |
| DAX | 8.77 | 0.003 | R |
| DEM | 16.82 | 0.000 | R |
| *SAC-based Model* | | | |
| DAX | 8.77 | 0.003 | R |
| DEM | 16.71 | 0.000 | R |

Note: Tests are on the null hypothesis that the particular series listed in the far left-hand column is not in the cointegration space. The heading "Decision" relates to the decision to reject (R) or fail to reject (F) the null hypothesis at a 5 % significance level. Under the null hypothesis, the test statistic is distributed chi-squared with one degree of freedom.

**Table 8.2. Tests on Exclusion of Japanese Stock Market and the Respective Exchange Rate from the Cointegration Space, 1973-1998**

| Stock Price Index and Exchange Rates (Currency/SAC) | Chi-Squared test | p-value | Decision |
|---|---|---|---|
| *Local Currency-based Model* | | | |
| NIKKEI | 10.46 | 0.001 | R |
| JPY | 16.33 | 0.000 | R |
| *SAC-based Model* | | | |
| NIKKEI | 10.46 | 0.001 | R |
| JPY | 16.89 | 0.000 | R |

Note: Tests are on the null hypothesis that the particular series listed in the far left-hand column is not in the cointegration space. The heading "Decision" relates to the decision to reject (R) or fail to reject (F) the null hypothesis at a 5 % significance level. Under the null hypothesis, the test statistic is distributed chi-squared with one degree of freedom.

[53] All abbreviations and acronyms are provided in Appendix A.

**Table 9.1. Tests on Weak Exogenity of German Stock Market and the Respective Exchange Rate, 1973-1998**[54]

| Stock Price Index and Exchange Rates (Currency/SAC) | Chi-Squared test | p-value | Decision |
|---|---|---|---|
| *Local Currency-based Model* | | | |
| DAX | 2.21 | 0.137 | F |
| DEM | 18.75 | 0.000 | R |
| *SAC-based Model* | | | |
| DAX | 8.74 | 0.003 | R |
| DEM | 18.75 | 0.000 | R |

Note: Tests are on the null hypothesis that the particular series listed in the far left-hand column is weakly exogenous with respect to perturbations in the cointegrating vector. The heading "Decision" relates to the decision to reject (R) or fail to reject (F) the null hypothesis of weak exogenity at a 5% significance level. Under the null hypothesis, the test statistic is distributed chi-squared with one degree of freedom.

**Table 9.2. Tests on Weak Exogenity of Japanese Stock Market and the Respective Exchange Rate, 1973-1998**

| Stock Price Index and Exchange Rates (Currency/SAC) | Chi-Squared test | p-value | Decision |
|---|---|---|---|
| *Local Currency-based Model* | | | |
| NIKKEI | 4.36 | 0.037 | R |
| JPY | 12.49 | 0.000 | R |
| *SAC-based Model* | | | |
| NIKKEI | 9.44 | 0.002 | R |
| JPY | 12.49 | 0.000 | R |

Note: Tests are on the null hypothesis that the particular series listed in the far left-hand column is weakly exogenous with respect to perturbations in the cointegrating vector. The heading "Decision" relates to the decision to reject (R) or fail to reject (F) the null hypothesis of weak exogenity at a 5% significance level. Under the null hypothesis, the test statistic is distributed chi-squared with one degree of freedom.

[54] All abbreviations and acronyms are provided in Appendix A.

**Table 10.1. Correlation Matrices of German Stock Market and the Respective Exchange Rate, 1973-1998**[55]

| | Local Currency-based Model | |
|---|---|---|
| | DAX | DEM |
| DAX | 1 | 0.09 |
| DEM | 0.09 | 1 |
| | SAC-based Model | |
| | DAX | DEM |
| DAX | 1 | -0.27 |
| DEM | -0.27 | 1 |

**Table 10.2. Correlation Matrices of Japanese Stock Markets and the Respective Exchange Rates, 1999-2004**

| | Local Currency-based Model | |
|---|---|---|
| | Nikkei | JPY |
| Nikkei | 1 | 0.01 |
| JPY | 0.01 | 1 |
| | SAC-based Model | |
| | Nikkei | JPY |
| Nikkei | 1 | -0.29 |
| JPY | -0.29 | 1 |

[55] All abbreviations and acronyms are provided in Appendix A.

**Table 11.1. F-Tests for Stock Markets and the Respective Exchange Rates, 1973-1998[56]**

| Dependent/ Independent | Nikkei | JPY | SP | USD | FTSE | GBP | DSFRA | FRF | AEX | ANG | DSITL | ITL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nikkei | 1299.15 (0) | 2.35 (0.09) | | | | | | | | | | |
| JPY | 1.23 (0.29) | 1371.75 (0) | | | | | | | | | | |
| SP | | | 1072.44 (0) | 2.35 (0.09) | | | | | | | | |
| USD | | | 9.42 (0) | 913.41 (0) | | | | | | | | |
| FTSE | | | | | 883.49 (0) | 28.84 (0) | | | | | | |
| GBP | | | | | 12.98 (0.00) | 1764.03 (0) | | | | | | |
| DSFRA | | | | | | | 1079.75 (0) | 23.93 (0) | | | | |
| FRF | | | | | | | 1.17 (0.31) | 2327.61 (0) | | | | |
| AEX | | | | | | | | | 1369.11 (0) | 104.31 (0) | | |
| ANG | | | | | | | | | 8.08 (0) | 2980.77 (0) | | |
| DSITL | | | | | | | | | | | 858.66 (0) | 86.37 (0) |
| ITL | | | | | | | | | | | 8.63 (0) | 2516.43 (0) |

Note: All the values are reported with their p-values, which appear in parentheses.

[56] All abbreviations and acronyms are provided in Appendix A.

**Table 11.2. F-Tests for Stock Markets and the Respective Exchange Rates, 1999-2004**[57]

| Dependent/ Independent | SP | USD | FTSE | GBP | DAX | EUR | DSFRA | EUR | AEX | EUR | DSITL | EUR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SP | 283.83 (0) | 0.51 (0.59) | | | | | | | | | | |
| USD | 38.53 (0) | 439.12 (0) | | | | | | | | | | |
| FTSE | | | 330.59 (0) | 2.10 (0.12) | | | | | | | | |
| GBP | | | 4.42 (0.01) | 260.31 (0) | | | | | | | | |
| DAX | | | | | 335.94 (0) | 0.86 (0.42) | | | | | | |
| EUR | | | | | 15.42 (0.00) | 341.26 (0) | | | | | | |
| DSFRA | | | | | | | 344.76 (0) | 1.18 (0.31) | | | | |
| EUR | | | | | | | 12.82 (0) | 333.64 (0) | | | | |
| AEX | | | | | | | | | 388.92 (0) | 0.67 (0.51) | | |
| EUR | | | | | | | | | 17.99 (0) | 341.56 (0) | | |
| DSITL | | | | | | | | | | | 387.00 (0) | 0.90 (0.41) |
| EUR | | | | | | | | | | | 8.63 (0) | 326.48 (0) |

Note: All the values are reported with their p-values, which appear in parentheses. Euro is used as a substitute for German mark, French franc, Netherlands' guilder and Italian lira.

[57] All abbreviations and acronyms are provided in Appendix A.

**Table 12.1. Forecast Error Decomposition of Japanese Stock Market and the Exchange Rates, 1973-1998[58]**

| Horizon | Nikkei | JPY | USD | GBP | DEM | FRF | ANG | ITL |
|---|---|---|---|---|---|---|---|---|
| | | | | (Nikkei) | | | | |
| 0 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1 | 99.83 | 0.04 | 0.01 | 0.00 | 0.03 | 0.00 | 0.08 | 0.00 |
| 12 | 99.52 | 0.07 | 0.02 | 0.03 | 0.12 | 0.00 | 0.23 | 0.01 |
| 24 | 99.15 | 0.07 | 0.01 | 0.08 | 0.18 | 0.00 | 0.46 | 0.05 |
| 35 | 98.76 | 0.06 | 0.01 | 0.12 | 0.24 | 0.00 | 0.69 | 0.11 |
| | | | | (JPY) | | | | |
| 0 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1 | 0.00 | 96.50 | 0.65 | 1.04 | 0.05 | 1.43 | 0.33 | 0.00 |
| 12 | 0.00 | 95.32 | 1.28 | 1.43 | 0.01 | 1.83 | 0.07 | 0.05 |
| 24 | 0.00 | 94.99 | 1.31 | 1.57 | 0.01 | 1.90 | 0.08 | 0.14 |
| 35 | 0.00 | 94.61 | 1.29 | 1.71 | 0.00 | 1.95 | 0.17 | 0.26 |
| | | | | (USD) | | | | |
| 0 | 0.00 | 0.25 | 49.31 | 0.50 | 35.70 | 13.78 | 0.00 | 0.47 |
| 1 | 0.00 | 0.33 | 33.11 | 0.19 | 30.86 | 13.12 | 7.58 | 14.81 |
| 12 | 0.02 | 0.21 | 30.18 | 0.31 | 30.20 | 13.25 | 8.75 | 17.29 |
| 24 | 0.03 | 0.21 | 29.31 | 0.44 | 28.97 | 12.97 | 10.06 | 18.20 |
| 35 | 0.03 | 0.23 | 28.54 | 0.57 | 27.84 | 12.68 | 11.24 | 18.88 |
| | | | | (GBP) | | | | |
| 0 | 0.00 | 2.41 | 0.00 | 97.59 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1 | 0.03 | 5.21 | 0.06 | 90.88 | 1.94 | 1.12 | 0.04 | 0.72 |
| 12 | 0.05 | 6.87 | 0.08 | 86.62 | 3.45 | 1.26 | 0.03 | 1.63 |
| 24 | 0.05 | 7.12 | 0.10 | 85.73 | 4.12 | 1.36 | 0.09 | 1.41 |
| 35 | 0.05 | 7.23 | 0.13 | 85.11 | 4.64 | 1.43 | 0.19 | 1.22 |

[58] All abbreviations and acronyms are provided in Appendix A.

**Table 12.1. Continued**

| Horizon | Nikkei | JPY | USD | GBP | DEM | FRF | ANG | ITL |
|---|---|---|---|---|---|---|---|---|
| | | | | (DEM) | | | | |
| 0 | 0.00 | 20.16 | 0.00 | 35.39 | 31.77 | 12.27 | 0.00 | 0.41 |
| 1 | 0.03 | 20.78 | 0.25 | 32.43 | 30.61 | 8.48 | 4.81 | 2.61 |
| 12 | 0.03 | 23.30 | 0.60 | 31.77 | 31.49 | 5.65 | 4.45 | 2.42 |
| 24 | 0.03 | 23.92 | 0.69 | 30.72 | 31.44 | 5.34 | 5.22 | 2.64 |
| 35 | 0.03 | 24.30 | 0.74 | 29.86 | 31.08 | 5.26 | 5.91 | 2.82 |
| | | | | (FRF) | | | | |
| 0 | 0.00 | 0.43 | 0.00 | 0.00 | 0.00 | 99.57 | 0.00 | 0.00 |
| 1 | 0.01 | 5.94 | 0.00 | 2.27 | 7.29 | 76.13 | 0.88 | 7.49 |
| 12 | 0.01 | 7.61 | 0.11 | 1.29 | 7.26 | 69.60 | 2.67 | 11.45 |
| 24 | 0.01 | 7.65 | 0.15 | 0.90 | 6.32 | 68.49 | 3.70 | 12.77 |
| 35 | 0.01 | 7.58 | 0.19 | 0.68 | 5.57 | 67.85 | 4.51 | 13.63 |
| | | | | (ANG) | | | | |
| 0 | 0.00 | 9.32 | 0.00 | 4.63 | 4.15 | 1.60 | 46.53 | 33.77 |
| 1 | 0.00 | 10.68 | 0.36 | 5.29 | 3.78 | 1.21 | 47.86 | 30.81 |
| 12 | 0.00 | 13.76 | 0.63 | 7.52 | 4.33 | 0.58 | 46.94 | 26.25 |
| 24 | 0.00 | 15.23 | 0.66 | 9.21 | 5.36 | 0.57 | 44.23 | 24.74 |
| 35 | 0.00 | 16.31 | 0.67 | 10.59 | 6.29 | 0.62 | 41.87 | 23.66 |
| | | | | (ITL) | | | | |
| 0 | 0.00 | 6.16 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 93.84 |
| 1 | 0.00 | 6.21 | 0.27 | 0.10 | 0.78 | 0.63 | 3.35 | 88.66 |
| 12 | 0.00 | 6.86 | 0.46 | 0.05 | 0.95 | 0.94 | 5.94 | 84.80 |
| 24 | 0.00 | 6.90 | 0.46 | 0.03 | 0.80 | 0.93 | 7.71 | 83.17 |
| 35 | 0.00 | 6.85 | 0.44 | 0.05 | 0.68 | 0.90 | 9.13 | 81.94 |

Note: Decompositions at each step are given for a “Bernanke” factorization of the innovation correlation/covariance matrix. The decompositions sum to one hundred in any row. Only SAC-based model results are reported.

**Table 12.2. Forecast Error Decomposition of U.S. Stock Market and the Exchange Rates, 1973-1998[59]**

| Horizon | SP | JPY | USD | GBP | DEM | FRF | ANG | ITL |
|---|---|---|---|---|---|---|---|---|
| | | | | (SP) | | | | |
| 0 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1 | 97.26 | 0.06 | 0.01 | 0.00 | 0.08 | 0.09 | 0.91 | 1.59 |
| 12 | 96.55 | 0.05 | 0.01 | 0.02 | 0.05 | 0.10 | 1.19 | 2.03 |
| 24 | 95.88 | 0.04 | 0.01 | 0.06 | 0.03 | 0.09 | 1.56 | 2.32 |
| 35 | 95.33 | 0.04 | 0.01 | 0.11 | 0.02 | 0.09 | 1.87 | 2.54 |
| | | | | (JPY) | | | | |
| 0 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1 | 0.02 | 96.51 | 0.64 | 1.04 | 0.03 | 1.41 | 0.33 | 0.00 |
| 12 | 0.08 | 95.45 | 1.26 | 1.33 | 0.02 | 1.73 | 0.12 | 0.01 |
| 24 | 0.08 | 95.43 | 1.30 | 1.32 | 0.03 | 1.76 | 0.08 | 0.01 |
| 35 | 0.08 | 95.45 | 1.31 | 1.29 | 0.00 | 1.77 | 0.06 | 0.01 |
| | | | | (USD) | | | | |
| 0 | 2.29 | 0.26 | 49.13 | 0.49 | 34.18 | 13.20 | 0.00 | 0.45 |
| 1 | 2.00 | 0.30 | 32.46 | 0.18 | 29.46 | 12.55 | 7.85 | 15.20 |
| 12 | 1.95 | 0.12 | 29.65 | 0.33 | 28.82 | 12.70 | 8.83 | 17.61 |
| 24 | 1.90 | 0.09 | 28.89 | 0.48 | 27.54 | 12.38 | 10.17 | 18.55 |
| 35 | 1.85 | 0.07 | 28.39 | 0.63 | 26.56 | 12.09 | 11.25 | 19.15 |
| | | | | (GBP) | | | | |
| 0 | 0.00 | 2.41 | 0.00 | 97.59 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1 | 0.00 | 4.92 | 0.06 | 91.17 | 1.95 | 1.14 | 0.04 | 0.72 |
| 12 | 0.00 | 6.63 | 0.08 | 86.97 | 3.42 | 1.25 | 0.04 | 1.61 |
| 24 | 0.00 | 7.14 | 0.10 | 85.89 | 4.03 | 1.32 | 0.12 | 1.40 |
| 35 | 0.00 | 7.49 | 0.12 | 85.07 | 4.48 | 1.36 | 0.25 | 1.23 |

[59] All abbreviations and acronyms are provided in Appendix A.

**Table 12.2. Continued**

| Horizon | SP | JPY | USD | GBP | DEM | FRF | ANG | ITL |
|---|---|---|---|---|---|---|---|---|
| | | | | (DEM) | | | | |
| 0 | 0.00 | 20.13 | 0.00 | 35.40 | 31.78 | 12.27 | 0.00 | 0.42 |
| 1 | 0.00 | 21.09 | 0.26 | 32.25 | 30.53 | 8.43 | 4.79 | 2.64 |
| 12 | 0.03 | 23.48 | 0.59 | 31.22 | 31.39 | 5.50 | 4.85 | 2.94 |
| 24 | 0.04 | 23.81 | 0.68 | 29.97 | 30.57 | 5.07 | 6.10 | 3.77 |
| 35 | 0.04 | 23.91 | 0.73 | 28.96 | 29.82 | 4.86 | 7.17 | 4.50 |
| | | | | (FRF) | | | | |
| 0 | 0.00 | 0.44 | 0.00 | 0.00 | 0.00 | 99.56 | 0.00 | 0.00 |
| 1 | 0.01 | 5.90 | 0.00 | 2.28 | 7.24 | 76.20 | 0.88 | 7.50 |
| 12 | 0.01 | 7.19 | 0.10 | 1.32 | 7.39 | 69.54 | 2.69 | 11.77 |
| 24 | 0.01 | 6.84 | 0.13 | 0.95 | 6.50 | 68.47 | 3.71 | 13.39 |
| 35 | 0.01 | 6.44 | 0.15 | 0.73 | 5.77 | 67.88 | 4.51 | 14.50 |
| | | | | (ANG) | | | | |
| 0 | 0.00 | 9.29 | 0.00 | 4.63 | 4.15 | 1.60 | 46.53 | 33.79 |
| 1 | 0.07 | 10.62 | 0.30 | 5.25 | 3.85 | 1.22 | 47.85 | 30.84 |
| 12 | 0.12 | 13.68 | 0.54 | 7.44 | 4.55 | 0.58 | 46.77 | 26.32 |
| 24 | 0.12 | 15.09 | 0.57 | 9.12 | 5.64 | 0.54 | 43.96 | 24.97 |
| 35 | 0.12 | 16.09 | 0.58 | 10.48 | 6.60 | 0.54 | 41.53 | 24.06 |
| | | | | (ITL) | | | | |
| 0 | 0.00 | 6.14 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 93.86 |
| 1 | 0.13 | 6.19 | 0.22 | 0.10 | 0.67 | 0.55 | 3.32 | 88.80 |
| 12 | 0.23 | 7.15 | 0.38 | 0.05 | 0.77 | 0.84 | 6.01 | 84.57 |
| 24 | 0.23 | 7.52 | 0.38 | 0.03 | 0.62 | 0.82 | 7.89 | 82.50 |
| 35 | 0.23 | 7.77 | 0.38 | 0.05 | 0.50 | 0.78 | 9.41 | 80.87 |

Note: Decompositions at each step are given for a “Bernanke” factorization of the innovation correlation/covariance matrix. The decompositions sum to one hundred in any row. Only SAC-based model results are reported.

**Table 12.3. Forecast Error Decomposition of U.K. Stock Market and the Exchange Rates, 1973-1998[60]**

| Horizon | FTSE | JPY | USD | GBP | DEM | FRF | ANG | ITL |
|---|---|---|---|---|---|---|---|---|
| | | | | (FTSE) | | | | |
| 0 | 95.90 | 0.87 | 0.00 | 1.32 | 1.19 | 0.46 | 0.11 | 0.15 |
| 1 | 97.62 | 0.73 | 0.01 | 0.58 | 0.71 | 0.20 | 0.08 | 0.07 |
| 12 | 98.29 | 0.83 | 0.01 | 0.10 | 0.58 | 0.10 | 0.04 | 0.04 |
| 24 | 98.34 | 0.84 | 0.01 | 0.06 | 0.55 | 0.09 | 0.05 | 0.05 |
| 35 | 98.35 | 0.84 | 0.01 | 0.04 | 0.53 | 0.09 | 0.07 | 0.06 |
| | | | | (JPY) | | | | |
| 0 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1 | 0.01 | 96.47 | 0.64 | 1.10 | 0.04 | 1.41 | 0.33 | 0.00 |
| 12 | 0.01 | 95.53 | 1.28 | 1.32 | 0.02 | 1.72 | 0.10 | 0.02 |
| 24 | 0.01 | 95.58 | 1.32 | 1.24 | 0.04 | 1.71 | 0.06 | 0.03 |
| 35 | 0.01 | 95.65 | 1.33 | 1.17 | 0.05 | 1.69 | 0.04 | 0.05 |
| | | | | (USD) | | | | |
| 0 | 0.00 | 0.24 | 49.30 | 0.47 | 35.72 | 13.80 | 0.00 | 0.47 |
| 1 | 0.03 | 0.27 | 33.18 | 0.16 | 30.78 | 13.10 | 7.61 | 14.87 |
| 12 | 0.07 | 0.10 | 30.43 | 0.25 | 29.69 | 13.08 | 8.73 | 17.65 |
| 24 | 0.08 | 0.07 | 29.57 | 0.40 | 28.05 | 12.60 | 10.16 | 19.07 |
| 35 | 0.09 | 0.05 | 28.97 | 0.55 | 26.79 | 12.18 | 11.29 | 20.08 |
| | | | | (GBP) | | | | |
| 0 | 0.00 | 2.46 | 0.00 | 97.54 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1 | 0.22 | 4.82 | 0.06 | 91.19 | 1.87 | 1.08 | 0.04 | 0.71 |
| 12 | 0.48 | 6.16 | 0.09 | 87.18 | 3.26 | 1.21 | 0.04 | 1.59 |
| 24 | 0.49 | 6.37 | 0.11 | 86.32 | 3.89 | 1.30 | 0.12 | 1.39 |
| 35 | 0.50 | 6.48 | 0.14 | 85.70 | 4.36 | 1.35 | 0.25 | 1.23 |

[60] All abbreviations and acronyms are provided in Appendix A.

**Table 12.3. Continued**

| Horizon | FTSE | JPY | USD | GBP | DEM | FRF | ANG | ITL |
|---|---|---|---|---|---|---|---|---|
| | | | | (DEM) | | | | |
| 0 | 0.00 | 20.13 | 0.00 | 35.33 | 31.83 | 12.30 | 0.00 | 0.42 |
| 1 | 0.14 | 21.42 | 0.24 | 31.51 | 30.73 | 8.51 | 4.79 | 2.65 |
| 12 | 0.24 | 24.54 | 0.59 | 29.89 | 31.40 | 5.54 | 4.87 | 2.92 |
| 24 | 0.25 | 25.26 | 0.70 | 28.86 | 30.20 | 5.00 | 6.15 | 3.60 |
| 35 | 0.24 | 25.67 | 0.77 | 28.08 | 29.11 | 4.70 | 7.27 | 4.16 |
| | | | | (FRF) | | | | |
| 0 | 0.00 | 0.44 | 0.00 | 0.00 | 0.00 | 99.56 | 0.00 | 0.00 |
| 1 | 0.01 | 5.90 | 0.00 | 2.37 | 7.29 | 76.02 | 0.87 | 7.55 |
| 12 | 0.00 | 7.84 | 0.12 | 1.39 | 7.42 | 68.90 | 2.72 | 11.62 |
| 24 | 0.00 | 8.07 | 0.17 | 1.07 | 6.57 | 67.32 | 3.83 | 12.97 |
| 35 | 0.00 | 8.16 | 0.21 | 0.88 | 5.88 | 66.30 | 4.74 | 13.83 |
| | | | | (ANG) | | | | |
| 0 | 0.00 | 9.30 | 0.00 | 4.62 | 4.16 | 1.61 | 46.49 | 33.81 |
| 1 | 0.01 | 10.66 | 0.35 | 5.19 | 3.81 | 1.22 | 47.90 | 30.86 |
| 12 | 0.03 | 13.82 | 0.62 | 7.19 | 4.42 | 0.56 | 47.28 | 26.09 |
| 24 | 0.04 | 15.29 | 0.64 | 8.79 | 5.48 | 0.52 | 44.86 | 24.37 |
| 35 | 0.05 | 16.38 | 0.65 | 10.13 | 6.43 | 0.53 | 42.71 | 23.13 |
| | | | | (ITL) | | | | |
| 0 | 0.00 | 6.13 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 93.87 |
| 1 | 0.05 | 6.27 | 0.27 | 0.15 | 0.73 | 0.60 | 3.34 | 88.57 |
| 12 | 0.18 | 7.55 | 0.46 | 0.11 | 0.77 | 0.90 | 6.13 | 83.90 |
| 24 | 0.22 | 8.11 | 0.47 | 0.06 | 0.58 | 0.91 | 8.13 | 81.52 |
| 35 | 0.24 | 8.54 | 0.46 | 0.06 | 0.45 | 0.90 | 9.74 | 79.61 |

Note: Decompositions at each step are given for a “Bernanke” factorization of the innovation correlation/covariance matrix. The decompositions sum to one hundred in any row. Only SAC-based model results are reported.

**Table 12.4. Forecast Error Decomposition of German Stock Market and the Exchange Rates, 1973-1998[61]**

| Horizon | DAX | JPY | USD | GBP | DEM | FRF | ANG | ITL |
|---|---|---|---|---|---|---|---|---|
| | | | | (DAX) | | | | |
| 0 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1 | 99.20 | 0.09 | 0.06 | 0.09 | 0.14 | 0.33 | 0.06 | 0.01 |
| 12 | 98.76 | 0.12 | 0.13 | 0.14 | 0.26 | 0.43 | 0.13 | 0.02 |
| 24 | 98.30 | 0.13 | 0.15 | 0.23 | 0.38 | 0.46 | 0.33 | 0.02 |
| 35 | 97.85 | 0.13 | 0.17 | 0.31 | 0.49 | 0.48 | 0.54 | 0.03 |
| | | | | (JPY) | | | | |
| 0 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1 | 0.08 | 96.51 | 0.66 | 1.00 | 0.04 | 1.38 | 0.33 | 0.00 |
| 12 | 0.08 | 95.52 | 1.31 | 1.25 | 0.02 | 1.70 | 0.11 | 0.01 |
| 24 | 0.08 | 95.54 | 1.36 | 1.21 | 0.03 | 1.71 | 0.06 | 0.02 |
| 35 | 0.08 | 95.59 | 1.37 | 1.16 | 0.04 | 1.70 | 0.04 | 0.02 |
| | | | | (USD) | | | | |
| 0 | 1.80 | 0.42 | 49.13 | 0.68 | 34.99 | 12.56 | 0.00 | 0.43 |
| 1 | 1.72 | 0.24 | 33.17 | 0.29 | 30.33 | 12.03 | 7.59 | 14.62 |
| 12 | 1.75 | 0.05 | 30.46 | 0.47 | 29.69 | 12.26 | 8.50 | 16.84 |
| 24 | 1.69 | 0.03 | 29.75 | 0.64 | 28.41 | 12.06 | 9.74 | 17.68 |
| 35 | 1.65 | 0.02 | 29.28 | 0.81 | 27.43 | 11.91 | 10.72 | 18.19 |
| | | | | (GBP) | | | | |
| 0 | 0.00 | 2.40 | 0.00 | 97.60 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1 | 0.08 | 4.78 | 0.06 | 91.33 | 1.95 | 1.06 | 0.04 | 0.71 |
| 12 | 0.10 | 6.45 | 0.07 | 87.16 | 3.47 | 1.17 | 0.05 | 1.54 |
| 24 | 0.11 | 6.95 | 0.09 | 86.00 | 4.14 | 1.24 | 0.16 | 1.30 |
| 35 | 0.13 | 7.30 | 0.11 | 85.09 | 4.65 | 1.28 | 0.33 | 1.11 |

[61] All abbreviations and acronyms are provided in Appendix A.

**Table 12.4. Continued**

| Horizon | DAX | JPY | USD | GBP | DEM | FRF | ANG | ITL |
|---|---|---|---|---|---|---|---|---|
| | | | | (DEM) | | | | |
| 0 | 1.65 | 19.37 | 0.00 | 35.02 | 32.07 | 11.51 | 0.00 | 0.39 |
| 1 | 1.30 | 20.49 | 0.25 | 31.87 | 30.72 | 7.83 | 4.91 | 2.62 |
| 12 | 1.10 | 23.09 | 0.62 | 30.82 | 31.30 | 4.98 | 5.11 | 2.98 |
| 24 | 1.04 | 23.52 | 0.72 | 29.49 | 30.28 | 4.57 | 6.52 | 3.87 |
| 35 | 1.00 | 23.69 | 0.78 | 28.40 | 29.36 | 4.39 | 7.73 | 4.65 |
| | | | | (FRF) | | | | |
| 0 | 2.38 | 0.70 | 0.00 | 0.00 | 0.00 | 96.92 | 0.00 | 0.00 |
| 1 | 1.31 | 6.23 | 0.00 | 2.07 | 7.08 | 74.97 | 0.89 | 7.45 |
| 12 | 0.62 | 8.24 | 0.10 | 1.21 | 7.26 | 68.45 | 2.64 | 11.47 |
| 24 | 0.58 | 8.52 | 0.15 | 0.91 | 6.53 | 66.85 | 3.58 | 12.89 |
| 35 | 0.58 | 8.66 | 0.18 | 0.72 | 5.93 | 65.79 | 4.30 | 13.84 |
| | | | | (ANG) | | | | |
| 0 | 0.21 | 9.04 | 0.00 | 4.48 | 4.10 | 1.47 | 46.85 | 33.84 |
| 1 | 0.17 | 10.42 | 0.36 | 5.16 | 3.74 | 1.11 | 48.19 | 30.86 |
| 12 | 0.13 | 13.51 | 0.63 | 7.35 | 4.27 | 0.51 | 47.27 | 26.33 |
| 24 | 0.15 | 14.93 | 0.66 | 8.99 | 5.28 | 0.50 | 44.54 | 24.94 |
| 35 | 0.18 | 15.95 | 0.67 | 10.33 | 6.18 | 0.53 | 42.15 | 24.01 |
| | | | | (ITL) | | | | |
| 0 | 0.00 | 6.16 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 93.84 |
| 1 | 0.06 | 6.28 | 0.27 | 0.85 | 0.75 | 0.58 | 3.35 | 88.61 |
| 12 | 0.09 | 7.31 | 0.47 | 0.04 | 0.87 | 0.86 | 6.42 | 83.94 |
| 24 | 0.08 | 7.69 | 0.47 | 0.03 | 0.69 | 0.85 | 8.78 | 81.41 |
| 35 | 0.07 | 7.93 | 0.46 | 0.06 | 0.56 | 0.83 | 10.75 | 79.36 |

Note: Decompositions at each step are given for a “Bernanke” factorization of the innovation correlation/covariance matrix. The decompositions sum to one hundred in any row. Only SAC-based model results are reported.

**Table 12.5. Forecast Error Decomposition of French Stock Market and the Exchange Rates, 1973-1998[62]**

| Horizon | DSFRA | JPY | USD | GBP | DEM | FRF | ANG | ITL |
|---|---|---|---|---|---|---|---|---|
| | | | | (DSFRA) | | | | |
| 0 | 96.48 | 0.16 | 0.00 | 0.03 | 0.03 | 2.73 | 0.34 | 0.23 |
| 1 | 93.71 | 0.08 | 0.00 | 0.07 | 0.43 | 5.35 | 0.24 | 0.12 |
| 12 | 93.01 | 0.01 | 0.00 | 0.02 | 0.49 | 6.34 | 0.08 | 0.05 |
| 24 | 93.00 | 0.01 | 0.00 | 0.01 | 0.48 | 6.39 | 0.06 | 0.05 |
| 35 | 93.03 | 0.00 | 0.00 | 0.01 | 0.47 | 6.38 | 0.04 | 0.06 |
| | | | | (JPY) | | | | |
| 0 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1 | 0.33 | 96.48 | 0.64 | 1.07 | 0.05 | 1.13 | 0.30 | 0.00 |
| 12 | 0.45 | 95.50 | 1.27 | 1.32 | 0.02 | 1.33 | 0.10 | 0.02 |
| 24 | 0.45 | 95.49 | 1.31 | 1.29 | 0.02 | 1.34 | 0.05 | 0.04 |
| 35 | 0.44 | 95.52 | 1.32 | 1.25 | 0.03 | 1.33 | 0.04 | 0.06 |
| | | | | (USD) | | | | |
| 0 | 3.31 | 0.21 | 49.13 | 0.26 | 36.29 | 10.78 | 0.01 | 0.01 |
| 1 | 2.81 | 0.30 | 33.89 | 0.08 | 32.02 | 10.77 | 8.27 | 11.85 |
| 12 | 2.36 | 0.13 | 31.27 | 0.18 | 31.24 | 11.30 | 9.53 | 13.98 |
| 24 | 2.21 | 0.10 | 30.39 | 0.32 | 29.61 | 10.97 | 11.04 | 15.37 |
| 35 | 2.09 | 0.08 | 29.76 | 0.45 | 28.34 | 10.66 | 12.23 | 16.40 |
| | | | | (GBP) | | | | |
| 0 | 0.00 | 2.41 | 0.00 | 97.59 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1 | 0.15 | 4.97 | 0.07 | 91.23 | 2.02 | 1.03 | 0.03 | 0.51 |
| 12 | 0.13 | 6.45 | 0.09 | 87.31 | 3.57 | 1.22 | 0.04 | 1.18 |
| 24 | 0.15 | 6.67 | 0.12 | 86.42 | 4.24 | 1.30 | 0.12 | 0.98 |
| 35 | 0.16 | 6.76 | 0.15 | 85.76 | 4.74 | 1.35 | 0.25 | 0.82 |

[62] All abbreviations and acronyms are provided in Appendix A.

**Table 12.5. Continued**

| Horizon | DSFRA | JPY | USD | GBP | DEM | FRF | ANG | ITL |
|---|---|---|---|---|---|---|---|---|
| | | | | (DEM) | | | | |
| 0 | 2.87 | 19.84 | 0.00 | 36.49 | 31.45 | 9.34 | 0.01 | 0.01 |
| 1 | 2.12 | 21.00 | 0.24 | 33.56 | 30.41 | 6.41 | 4.85 | 1.41 |
| 12 | 1.49 | 23.99 | 0.59 | 32.45 | 31.12 | 4.07 | 4.99 | 1.29 |
| 24 | 1.36 | 24.97 | 0.69 | 31.03 | 30.29 | 3.72 | 6.21 | 1.72 |
| 35 | 1.29 | 25.64 | 0.76 | 29.86 | 29.51 | 3.55 | 7.26 | 2.12 |
| | | | | (FRF) | | | | |
| 0 | 17.99 | 0.34 | 0.00 | 0.01 | 0.01 | 81.56 | 0.06 | 0.04 |
| 1 | 14.69 | 5.83 | 0.00 | 2.47 | 7.42 | 63.21 | 0.73 | 5.66 |
| 12 | 15.03 | 7.69 | 0.10 | 1.14 | 7.49 | 56.79 | 2.32 | 9.16 |
| 24 | 14.99 | 7.91 | 0.14 | 1.01 | | 55.33 | 3.44 | 10.63 |
| 35 | 14.90 | 7.99 | 0.18 | 0.77 | 5.80 | 54.35 | 4.37 | 11.62 |
| | | | | (ANG) | | | | |
| 0 | 0.28 | 9.38 | 0.00 | 4.81 | 4.14 | 1.26 | 47.86 | 32.26 |
| 1 | 0.22 | 10.71 | 0.35 | 5.46 | 3.76 | 0.96 | 49.16 | 29.38 |
| 12 | 0.06 | 13.77 | 0.61 | 7.71 | 4.32 | 0.47 | 48.57 | 24.48 |
| 24 | 0.05 | 15.25 | 0.64 | 9.43 | 5.37 | 0.44 | 46.20 | 22.60 |
| 35 | 0.05 | 16.36 | 0.64 | 10.83 | 6.32 | 0.44 | 44.08 | 21.27 |
| | | | | (ITL) | | | | |
| 0 | 0.00 | 6.16 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 93.84 |
| 1 | 0.17 | 6.19 | 0.26 | 0.10 | 0.75 | 0.44 | 3.40 | 88.68 |
| 12 | 0.22 | 7.38 | 0.46 | 0.04 | 0.80 | 0.68 | 6.00 | 84.42 |
| 24 | 0.21 | 8.10 | 0.48 | 0.06 | 0.57 | 0.69 | 7.73 | 82.17 |
| 35 | 0.19 | 8.71 | 0.48 | 0.13 | 0.42 | 0.67 | 9.06 | 80.33 |

Note: Decompositions at each step are given for a “Bernanke” factorization of the innovation correlation/covariance matrix. The decompositions sum to one hundred in any row. Only SAC-based model results are reported.

**Table 12.6. Forecast Error Decomposition of Netherlands Stock Market and the Exchange Rates, 1973-1998[63]**

| Horizon | AEX | JPY | USD | GBP | DEM | FRF | ANG | ITL |
|---|---|---|---|---|---|---|---|---|
| | | | | (AEX) | | | | |
| 0 | 58.22 | 2.43 | 0.00 | 4.33 | 3.75 | 1.88 | 27.28 | 2.11 |
| 1 | 66.32 | 2.62 | 0.30 | 3.54 | 2.49 | 1.23 | 20.12 | 3.38 |
| 12 | 75.01 | 3.44 | 0.52 | 3.31 | 1.11 | 0.30 | 10.87 | 4.59 |
| 24 | 77.72 | 3.75 | 0.52 | 3.64 | 1.13 | 0.19 | 8.03 | 5.02 |
| 35 | 78.55 | 3.95 | 0.51 | 3.93 | 1.23 | 0.15 | 6.39 | 5.29 |
| | | | | (JPY) | | | | |
| 0 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1 | 0.06 | 96.49 | 0.66 | 1.02 | 0.04 | 1.42 | 0.30 | 0.01 |
| 12 | 0.04 | 95.45 | 1.30 | 1.32 | 0.01 | 1.78 | 0.09 | 0.01 |
| 24 | 0.04 | 95.46 | 1.34 | 1.29 | 0.02 | 1.80 | 0.05 | 0.01 |
| 35 | 0.04 | 95.50 | 1.35 | 1.26 | 0.02 | 1.79 | 0.03 | 0.01 |
| | | | | (USD) | | | | |
| 0 | 0.05 | 0.22 | 48.68 | 0.30 | 35.96 | 14.28 | 0.02 | 0.49 |
| 1 | 1.04 | 0.09 | 31.31 | 0.46 | 36.12 | 15.81 | 14.96 | 0.23 |
| 12 | 1.10 | 0.01 | 28.44 | 0.16 | 36.87 | 16.52 | 16.70 | 0.21 |
| 24 | 1.07 | 0.01 | 27.74 | 0.10 | 35.90 | 16.30 | 18.71 | 0.17 |
| 35 | 1.03 | 0.02 | 27.27 | 0.07 | 35.09 | 16.07 | 20.30 | 0.14 |
| | | | | (GBP) | | | | |
| 0 | 0.00 | 2.44 | 0.00 | 97.56 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1 | 0.54 | 4.76 | 0.08 | 90.69 | 2.45 | 1.43 | 0.03 | 0.02 |
| 12 | 0.91 | 6.07 | 0.11 | 86.28 | 4.59 | 1.80 | 0.24 | 0.01 |
| 24 | 0.93 | 6.21 | 0.14 | 85.41 | 5.27 | 1.89 | 0.14 | 0.00 |
| 35 | 0.93 | 6.22 | 0.17 | 84.80 | 5.76 | 1.95 | 0.17 | 0.00 |

[63] All abbreviations and acronyms are provided in Appendix A.

**Table 12.6. Continued**

| Horizon | AEX | JPY | USD | GBP | DEM | FRF | ANG | ITL |
|---|---|---|---|---|---|---|---|---|
| | | | | (DEM) | | | | |
| 0 | 0.00 | 19.65 | 0.00 | 36.37 | 31.46 | 12.52 | 0.00 | 0.00 |
| 1 | 0.10 | 19.61 | 0.27 | 34.19 | 31.13 | 8.78 | 5.90 | 0.00 |
| 12 | 0.13 | 21.53 | 0.63 | 33.60 | 32.16 | 6.08 | 5.88 | 0.00 |
| 24 | 0.11 | 21.49 | 0.72 | 32.73 | 31.64 | 5.76 | 7.42 | 0.00 |
| 35 | 0.09 | 21.34 | 0.77 | 32.00 | 31.11 | 5.63 | 9.06 | 0.01 |
| | | | | (FRF) | | | | |
| 0 | 0.00 | 0.44 | 0.00 | 0.00 | 0.00 | 99.56 | 0.00 | 0.00 |
| 1 | 2.18 | 4.93 | 0.00 | 4.53 | 10.49 | 73.53 | 4.34 | 0.00 |
| 12 | 2.74 | 6.45 | 0.12 | 3.83 | 12.00 | 65.19 | 9.68 | 0.01 |
| 24 | 2.89 | 6.52 | 0.17 | 3.42 | 11.36 | 63.35 | 12.29 | 0.00 |
| 35 | 2.99 | 6.51 | 0.21 | 3.12 | 10.72 | 62.18 | 14.27 | 0.00 |
| | | | | (ANG) | | | | |
| 0 | 0.65 | 5.82 | 0.00 | 10.94 | 9.46 | 3.83 | 68.86 | 0.45 |
| 1 | 0.51 | 7.05 | 0.35 | 11.50 | 8.68 | 3.03 | 68.42 | 0.47 |
| 12 | 0.13 | 9.76 | 0.61 | 13.91 | 8.96 | 1.81 | 64.33 | 0.49 |
| 24 | 0.09 | 11.02 | 0.64 | 15.78 | 10.12 | 1.70 | 60.21 | 0.43 |
| 35 | 0.08 | 11.94 | 0.64 | 17.25 | 11.15 | 1.68 | 56.87 | 0.38 |
| | | | | (ITL) | | | | |
| 0 | 8.76 | 0.11 | 0.00 | 0.65 | 0.56 | 0.28 | 4.11 | 85.52 |
| 1 | 7.40 | 0.07 | 0.10 | 0.48 | 0.38 | 0.24 | 2.76 | 88.56 |
| 12 | 6.53 | 0.02 | 0.13 | 0.47 | 0.47 | 0.08 | 0.60 | 92.12 |
| 24 | 6.50 | 6.40 | 0.02 | 0.13 | 0.46 | 0.05 | 0.36 | 92.54 |
| 35 | 6.34 | 0.02 | 0.12 | 0.46 | 0.04 | 0.02 | 0.26 | 92.74 |

Note: Decompositions at each step are given for a "Bernanke" factorization of the innovation correlation/covariance matrix. The decompositions sum to one hundred in any row. Only SAC-based model results are reported.

**Table 12.7. Forecast Error Decomposition of Italian Stock Market and the Exchange Rates, 1973-1998[64]**

| Horizon | DSITL | JPY | USD | GBP | DEM | FRF | ANG | ITL |
|---|---|---|---|---|---|---|---|---|
| | | | | (DSITL) | | | | |
| 0 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1 | 97.99 | 0.01 | 0.00 | 0.12 | 0.09 | 0.03 | 0.36 | 1.40 |
| 12 | 97.45 | 0.00 | 0.03 | 0.15 | 0.03 | 0.01 | 0.42 | 1.92 |
| 24 | 96.99 | 0.00 | 0.03 | 0.11 | 0.02 | 0.00 | 0.64 | 2.20 |
| 35 | 96.59 | 0.00 | 0.04 | 0.08 | 0.01 | 0.00 | 0.84 | 2.42 |
| | | | | (JPY) | | | | |
| 0 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1 | 0.01 | 96.46 | 0.64 | 1.06 | 0.05 | 1.44 | 0.33 | 0.01 |
| 12 | 0.01 | 95.49 | 1.28 | 1.30 | 0.02 | 1.77 | 0.12 | 0.02 |
| 24 | 0.01 | 95.50 | 1.33 | 1.24 | 0.03 | 1.80 | 0.07 | 0.02 |
| 35 | 0.01 | 95.54 | 1.34 | 1.19 | 0.04 | 1.80 | 0.05 | 0.03 |
| | | | | (USD) | | | | |
| 0 | 0.45 | 0.20 | 48.63 | 0.25 | 36.09 | 14.38 | 0.00 | 0.00 |
| 1 | 0.52 | 0.20 | 34.07 | 0.08 | 32.52 | 14.24 | 7.83 | 10.50 |
| 12 | 0.42 | 0.08 | 31.60 | 0.18 | 31.99 | 14.76 | 8.73 | 12.24 |
| 24 | 0.48 | 0.06 | 30.87 | 0.32 | 30.43 | 14.64 | 9.86 | 13.35 |
| 35 | 0.53 | 0.04 | 30.37 | 0.46 | 29.20 | 14.54 | 10.70 | 14.17 |
| | | | | (GBP) | | | | |
| 0 | 0.00 | 2.41 | 0.00 | 97.59 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1 | 0.04 | 4.91 | 0.06 | 91.33 | 1.99 | 1.19 | 0.04 | 0.44 |
| 12 | 0.11 | 6.35 | 0.08 | 87.44 | 3.55 | 1.36 | 0.04 | 1.07 |
| 24 | 0.09 | 6.56 | 0.10 | 86.46 | 4.28 | 1.49 | 0.10 | 0.91 |
| 35 | 0.08 | 6.64 | 0.13 | 85.71 | 4.87 | 1.59 | 0.20 | 0.79 |

[64] All abbreviations and acronyms are provided in Appendix A.

**Table 12.7. Continued**

| Horizon | DSITL | JPY | USD | GBP | DEM | FRF | ANG | ITL |
|---|---|---|---|---|---|---|---|---|
| | | | | (DEM) | | | | |
| 0 | 0.00 | 19.67 | 0.00 | 36.42 | 31.39 | 12.51 | 0.00 | 0.00 |
| 1 | 0.12 | 21.00 | 0.24 | 33.69 | 30.51 | 8.77 | 4.70 | 1.12 |
| 12 | 0.18 | 23.12 | 0.59 | 33.03 | 31.60 | 5.83 | 4.61 | 1.05 |
| 24 | 0.24 | 23.51 | 0.68 | 32.01 | 31.09 | 5.42 | 5.64 | 1.41 |
| 35 | 0.30 | 23.67 | 0.74 | 31.15 | 30.59 | 5.24 | 6.54 | 1.78 |
| | | | | (FRF) | | | | |
| 0 | 0.00 | 0.43 | 0.00 | 0.00 | 0.00 | 99.57 | 0.00 | 0.00 |
| 1 | 0.81 | 5.73 | 0.00 | 2.54 | 7.55 | 77.16 | 0.91 | 5.30 |
| 12 | 1.56 | 7.41 | 0.12 | 1.53 | 7.67 | 69.99 | 2.97 | 8.75 |
| 24 | 1.81 | 7.52 | 0.16 | 1.15 | 6.78 | 68.03 | 4.30 | 10.25 |
| 35 | 1.97 | 7.53 | 0.20 | 0.92 | 6.06 | 66.63 | 5.37 | 11.31 |
| | | | | (ANG) | | | | |
| 0 | 3.05 | 8.77 | 0.00 | 4.94 | 4.26 | 1.70 | 47.91 | 29.36 |
| 1 | 2.93 | 10.06 | 0.36 | 5.60 | 3.87 | 1.28 | 49.21 | 26.69 |
| 12 | 2.74 | 13.15 | 0.62 | 7.92 | 4.46 | 0.59 | 48.19 | 22.33 |
| 24 | 2.63 | 14.54 | 0.65 | 9.61 | 5.49 | 0.54 | 45.37 | 20.83 |
| 35 | 2.53 | 15.74 | 0.66 | 11.25 | 6.60 | 0.55 | 42.88 | 19.80 |
| | | | | (ITL) | | | | |
| 0 | 13.42 | 4.90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 81.68 |
| 1 | 13.99 | 4.86 | 0.26 | 0.11 | 0.77 | 0.64 | 3.31 | 76.07 |
| 12 | 14.98 | 5.73 | 0.43 | 0.06 | 0.87 | 0.97 | 5.80 | 71.16 |
| 24 | 14.94 | 6.17 | 0.44 | 0.04 | 0.69 | 1.00 | 7.51 | 69.21 |
| 35 | 14.82 | 6.51 | 0.43 | 0.06 | 0.55 | 1.02 | 8.87 | 67.74 |

Note: Decompositions at each step are given for a “Bernanke” factorization of the innovation correlation/covariance matrix. The decompositions sum to one hundred in any row. Only SAC-based model results are reported.

**Table 13.1. Forecast Error Decomposition of Japanese Stock Market and the Exchange Rates, 1999-2004**[65]

| Horizon | Nikkei | JPY | USD | GBP | EUR |
|---|---|---|---|---|---|
| | | | (Nikkei) | | |
| 0 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1 | 99.53 | 0.00 | 0.03 | 0.34 | 0.10 |
| 12 | 98.75 | 0.07 | 0.31 | 0.70 | 0.17 |
| 24 | 98.75 | 0.07 | 0.31 | 0.70 | 0.17 |
| 35 | 98.75 | 0.07 | 0.31 | 0.70 | 0.17 |
| | | | (JPY) | | |
| 0 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 |
| 1 | 0.09 | 99.59 | 0.00 | 0.31 | 0.00 |
| 12 | 0.21 | 98.87 | 0.15 | 0.65 | 0.12 |
| 24 | 0.21 | 98.87 | 0.15 | 0.65 | 0.12 |
| 35 | 0.21 | 98.87 | 0.15 | 0.65 | 0.12 |
| | | | (USD) | | |
| 0 | 0.44 | 1.95 | 1.70 | 36.36 | 59.56 |
| 1 | 0.80 | 2.19 | 1.53 | 37.64 | 57.83 |
| 12 | 1.04 | 2.29 | 1.51 | 38.27 | 56.89 |
| 24 | 1.04 | 2.29 | 1.51 | 38.27 | 56.89 |
| 35 | 1.04 | 2.29 | 1.51 | 38.27 | 56.89 |
| | | | (GBP) | | |
| 0 | 0.00 | 33.35 | 0.00 | 66.65 | 0.00 |
| 1 | 0.03 | 34.56 | 0.06 | 65.32 | 0.03 |
| 12 | 0.19 | 34.59 | 0.13 | 64.84 | 0.26 |
| 24 | 0.19 | 34.59 | 0.13 | 64.84 | 0.26 |
| 35 | 0.19 | 34.59 | 0.13 | 64.84 | 0.26 |
| | | | (EUR) | | |
| 0 | 0.55 | 25.32 | 0.00 | 0.00 | 74.13 |
| 1 | 0.75 | 24.07 | 0.00 | 0.07 | 75.12 |
| 12 | 0.91 | 23.41 | 0.15 | 0.68 | 74.84 |
| 24 | 0.91 | 23.41 | 0.15 | 0.68 | 74.84 |
| 35 | 0.91 | 23.41 | 0.15 | 0.68 | 74.84 |

Note: Euro substitutes German mark, French franc, Netherlands' guilder, and Italian lira. Decompositions at each step are given for a "Bernanke" factorization of the innovation correlation/ covariance matrix. The decompositions sum to one hundred in any row. Only SAC-based model results are reported.

[65] All abbreviations and acronyms are provided in Appendix A.

**Table 13.2. Forecast Error Decomposition of U.S. Stock Market and the Exchange Rates, 1999-2004**[66]

| Horizon | SP | JPY | USD | GBP | EUR |
|---|---|---|---|---|---|
| | | | (SP) | | |
| 0 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1 | 99.79 | 0.07 | 0.01 | 0.13 | 0.00 |
| 12 | 99.43 | 0.13 | 0.13 | 0.26 | 0.05 |
| 24 | 99.43 | 0.13 | 0.13 | 0.26 | 0.05 |
| 35 | 99.43 | 0.13 | 0.13 | 0.26 | 0.05 |
| | | | (JPY) | | |
| 0 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 |
| 1 | 0.15 | 99.56 | 0.00 | 0.29 | 0.00 |
| 12 | 0.74 | 98.55 | 0.14 | 0.54 | 0.03 |
| 24 | 0.74 | 98.55 | 0.14 | 0.54 | 0.03 |
| 35 | 0.74 | 98.55 | 0.14 | 0.54 | 0.03 |
| | | | (USD) | | |
| 0 | 0.00 | 1.80 | 1.75 | 37.51 | 58.94 |
| 1 | 1.59 | 1.96 | 1.56 | 38.58 | 56.31 |
| 12 | 4.14 | 1.95 | 1.48 | 38.30 | 54.12 |
| 24 | 4.14 | 1.95 | 1.48 | 38.30 | 54.12 |
| 35 | 4.14 | 1.95 | 1.48 | 38.30 | 54.12 |
| | | | (GBP) | | |
| 0 | 0.00 | 33.28 | 0.00 | 66.72 | 0.00 |
| 1 | 0.11 | 34.02 | 0.06 | 65.80 | 0.02 |
| 12 | 0.22 | 34.08 | 0.13 | 65.30 | 0.27 |
| 24 | 0.22 | 34.08 | 0.13 | 65.30 | 0.27 |
| 35 | 0.22 | 34.08 | 0.13 | 65.30 | 0.27 |
| | | | (EUR) | | |
| 0 | 0.00 | 26.82 | 0.00 | 0.00 | 73.18 |
| 1 | 2.42 | 23.85 | 0.01 | 0.27 | 73.54 |
| 12 | 8.03 | 21.87 | 0.10 | 0.66 | 69.34 |
| 24 | 8.03 | 21.87 | 0.10 | 0.66 | 69.34 |
| 35 | 8.03 | 21.87 | 0.10 | 0.66 | 69.34 |

Note: Euro substitutes German mark, French franc, Netherlands' guilder, and Italian lira. Decompositions at each step are given for a "Bernanke" factorization of the innovation correlation/ covariance matrix. The decompositions sum to one hundred in any row. Only SAC-based model results are reported.

[66] All abbreviations and acronyms are provided in Appendix A.

**Table 13.3. Forecast Error Decomposition of U.K. Stock Market and the Exchange Rates, 1999-2004**[67]

| Horizon | FTSE | JPY | USD | GBP | EUR |
|---|---|---|---|---|---|
| | | | (FTSE) | | |
| 0 | 91.61 | 2.80 | 0.00 | 5.59 | 0.00 |
| 1 | 92.31 | 3.08 | 0.00 | 4.61 | 0.00 |
| 12 | 92.17 | 3.16 | 0.07 | 4.58 | 0.02 |
| 24 | 92.17 | 3.16 | 0.07 | 4.58 | 0.02 |
| 35 | 92.17 | 3.16 | 0.07 | 4.58 | 0.02 |
| | | | (JPY) | | |
| 0 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 |
| 1 | 0.00 | 99.59 | 0.01 | 0.40 | 0.00 |
| 12 | 0.22 | 98.66 | 0.17 | 0.84 | 0.12 |
| 24 | 0.22 | 98.66 | 0.17 | 0.84 | 0.12 |
| 35 | 0.22 | 98.66 | 0.17 | 0.84 | 0.12 |
| | | | (USD) | | |
| 0 | 0.00 | 1.53 | 1.72 | 36.47 | 60.29 |
| 1 | 0.78 | 1.57 | 1.55 | 37.67 | 58.43 |
| 12 | 1.67 | 1.59 | 1.52 | 37.95 | 57.27 |
| 24 | 1.67 | 1.59 | 1.52 | 37.95 | 57.27 |
| 35 | 1.67 | 1.59 | 1.52 | 37.95 | 57.27 |
| | | | (GBP) | | |
| 0 | 0.00 | 33.41 | 0.00 | 66.59 | 0.00 |
| 1 | 0.31 | 34.36 | 0.06 | 65.22 | 0.05 |
| 12 | 0.78 | 34.29 | 0.15 | 64.51 | 0.27 |
| 24 | 0.78 | 34.29 | 0.15 | 64.51 | 0.27 |
| 35 | 0.78 | 34.29 | 0.15 | 64.51 | 0.27 |
| | | | (EUR) | | |
| 0 | 0.00 | 26.82 | 0.00 | 0.00 | 73.18 |
| 1 | 0.29 | 25.73 | 0.00 | 0.06 | 73.92 |
| 12 | 1.06 | 24.90 | 0.15 | 0.63 | 73.27 |
| 24 | 1.06 | 24.90 | 0.15 | 0.63 | 73.27 |
| 35 | 1.06 | 24.90 | 0.15 | 0.63 | 73.27 |

Note: Euro substitutes German mark, French franc, Netherlands' guilder, and Italian lira. Decompositions at each step are given for a "Bernanke" factorization of the innovation correlation/ covariance matrix. The decompositions sum to one hundred in any row. Only SAC-based model results are reported.

[67] All abbreviations and acronyms are provided in Appendix A.

**Table 13.4. Forecast Error Decomposition of German Stock Market and the Exchange Rates, 1999-2004**[68]

| Horizon | DAX | JPY | USD | GBP | EUR |
|---|---|---|---|---|---|
| | | | (DAX) | | |
| 0 | 95.55 | 1.19 | 0.00 | 0.00 | 3.26 |
| 1 | 95.11 | 1.54 | 0.02 | 0.01 | 3.32 |
| 12 | 94.58 | 1.79 | 0.06 | 0.15 | 3.42 |
| 24 | 94.58 | 1.79 | 0.06 | 0.15 | 3.42 |
| 35 | 94.58 | 1.79 | 0.06 | 0.15 | 3.42 |
| | | | (JPY) | | |
| 0 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 |
| 1 | 0.04 | 99.51 | 0.01 | 0.44 | 0.01 |
| 12 | 0.64 | 98.05 | 0.19 | 0.97 | 0.15 |
| 24 | 0.64 | 98.05 | 0.19 | 0.97 | 0.15 |
| 35 | 0.64 | 98.05 | 0.19 | 0.97 | 0.15 |
| | | | (USD) | | |
| 0 | 0.00 | 1.66 | 1.73 | 36.75 | 59.86 |
| 1 | 1.28 | 1.79 | 1.53 | 37.68 | 57.73 |
| 12 | 2.93 | 1.83 | 1.48 | 37.69 | 56.06 |
| 24 | 2.93 | 1.83 | 1.48 | 37.69 | 56.06 |
| 35 | 2.93 | 1.83 | 1.48 | 37.69 | 56.06 |
| | | | (GBP) | | |
| 0 | 0.00 | 33.11 | 0.00 | 66.89 | 0.00 |
| 1 | 0.26 | 34.10 | 0.08 | 65.47 | 0.09 |
| 12 | 1.28 | 33.81 | 0.20 | 64.38 | 0.33 |
| 24 | 1.28 | 33.81 | 0.20 | 64.38 | 0.33 |
| 35 | 1.28 | 33.81 | 0.20 | 64.38 | 0.33 |
| | | | (EUR) | | |
| 0 | 0.00 | 26.77 | 0.00 | 0.00 | 73.23 |
| 1 | 1.00 | 25.39 | 0.00 | 0.00 | 73.57 |
| 12 | 2.94 | 24.29 | 0.16 | 0.57 | 72.04 |
| 24 | 2.94 | 24.29 | 0.16 | 0.57 | 72.04 |
| 35 | 2.94 | 24.29 | 0.16 | 0.57 | 72.04 |

Note: Euro substitutes German mark, French franc, Netherlands’ guilder, and Italian lira. Decompositions at each step are given for a “Bernanke” factorization of the innovation correlation/ covariance matrix. The decompositions sum to one hundred in any row. Only SAC-based model results are reported.

[68] All abbreviations and acronyms are provided in Appendix A.

**Table 13.5. Forecast Error Decomposition of French Stock Market and the Exchange Rates, 1999-2004**[69]

| Horizon | DSFRA | JPY | USD | GBP | EUR |
|---|---|---|---|---|---|
| | | | (DSFRA) | | |
| 0 | 96.14 | 3.86 | 0.00 | 0.00 | 0.00 |
| 1 | 95.99 | 3.96 | 0.01 | 0.02 | 0.02 |
| 12 | 95.27 | 4.30 | 0.08 | 0.21 | 0.16 |
| 24 | 95.27 | 4.30 | 0.08 | 0.21 | 0.16 |
| 35 | 95.27 | 4.30 | 0.08 | 0.21 | 0.16 |
| | | | (JPY) | | |
| 0 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 |
| 1 | 0.06 | 99.52 | 0.01 | 0.40 | 0.01 |
| 12 | 0.43 | 98.31 | 0.16 | 0.87 | 0.22 |
| 24 | 0.43 | 98.31 | 0.16 | 0.87 | 0.22 |
| 35 | 0.43 | 98.31 | 0.16 | 0.87 | 0.22 |
| | | | (USD) | | |
| 0 | 0.00 | 1.64 | 1.72 | 36.68 | 59.95 |
| 1 | 1.14 | 1.70 | 1.60 | 38.43 | 57.13 |
| 12 | 2.56 | 1.76 | 1.56 | 38.65 | 55.48 |
| 24 | 2.56 | 1.76 | 1.56 | 38.65 | 55.48 |
| 35 | 2.56 | 1.76 | 1.56 | 38.65 | 55.48 |
| | | | (GBP) | | |
| 0 | 0.00 | 33.21 | 0.00 | 66.79 | 0.00 |
| 1 | 0.33 | 34.21 | 0.07 | 65.26 | 0.14 |
| 12 | 0.95 | 34.08 | 0.16 | 64.48 | 0.34 |
| 24 | 0.95 | 34.08 | 0.16 | 64.48 | 0.34 |
| 35 | 0.95 | 34.08 | 0.16 | 64.48 | 0.34 |
| | | | (EUR) | | |
| 0 | 0.00 | 26.73 | 0.00 | 0.00 | 73.27 |
| 1 | 0.89 | 26.07 | 0.00 | 0.05 | 72.99 |
| 12 | 2.56 | 25.10 | 0.14 | 0.58 | 71.62 |
| 24 | 2.56 | 25.10 | 0.14 | 0.58 | 71.62 |
| 35 | 2.56 | 25.10 | 0.14 | 0.58 | 71.62 |

Note: Euro substitutes German mark, French franc, Netherlands' guilder, and Italian lira. Decompositions at each step are given for a "Bernanke" factorization of the innovation correlation/ covariance matrix. The decompositions sum to one hundred in any row. Only SAC-based model results are reported.

[69] All abbreviations and acronyms are provided in Appendix A.

**Table 13.6. Forecast Error Decomposition of Netherlands Stock Market and the Exchange Rates, 1999-2004**[70]

| Horizon | AEX | JPY | USD | GBP | EUR |
|---|---|---|---|---|---|
| | | | (AEX) | | |
| 0 | 97.31 | 2.69 | 0.00 | 0.00 | 0.00 |
| 1 | 96.98 | 3.00 | 0.00 | 0.01 | 0.00 |
| 12 | 96.61 | 3.32 | 0.03 | 0.02 | 0.03 |
| 24 | 96.61 | 3.32 | 0.03 | 0.02 | 0.03 |
| 35 | 96.61 | 3.32 | 0.03 | 0.02 | 0.03 |
| | | | (JPY) | | |
| 0 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 |
| 1 | 0.02 | 99.58 | 0.01 | 0.39 | 0.01 |
| 12 | 0.36 | 98.41 | 0.18 | 0.83 | 0.21 |
| 24 | 0.36 | 98.41 | 0.18 | 0.83 | 0.21 |
| 35 | 0.36 | 98.41 | 0.18 | 0.83 | 0.21 |
| | | | (USD) | | |
| 0 | 0.00 | 1.60 | 1.73 | 37.04 | 59.63 |
| 1 | 1.19 | 1.65 | 1.57 | 38.69 | 56.90 |
| 12 | 2.55 | 1.68 | 1.53 | 39.01 | 55.23 |
| 24 | 2.55 | 1.68 | 1.53 | 39.01 | 55.23 |
| 35 | 2.55 | 1.68 | 1.53 | 39.01 | 55.23 |
| | | | (GBP) | | |
| 0 | 0.00 | 33.25 | 0.00 | 66.75 | 0.00 |
| 1 | 0.04 | 34.35 | 0.07 | 65.45 | 0.09 |
| 12 | 0.37 | 34.32 | 0.17 | 64.90 | 0.24 |
| 24 | 0.37 | 34.32 | 0.17 | 64.90 | 0.24 |
| 35 | 0.37 | 34.32 | 0.17 | 64.90 | 0.24 |
| | | | (EUR) | | |
| 0 | 0.00 | 27.01 | 0.00 | 0.00 | 72.99 |
| 1 | 1.29 | 26.26 | 0.00 | 0.06 | 72.39 |
| 12 | 3.32 | 25.20 | 0.14 | 0.62 | 70.71 |
| 24 | 3.32 | 25.20 | 0.14 | 0.62 | 70.71 |
| 35 | 3.32 | 25.20 | 0.14 | 0.62 | 70.71 |

Note: Euro substitutes German mark, French franc, Netherlands' guilder, and Italian lira. Decompositions at each step are given for a "Bernanke" factorization of the innovation correlation/ covariance matrix. The decompositions sum to one hundred in any row. Only SAC-based model results are reported.

[70] All abbreviations and acronyms are provided in Appendix A.

**Table 13.7. Forecast Error Decomposition of Italian Stock Market and the Exchange Rates, 1999-2004**[71]

| Horizon | DSITL | JPY | USD | GBP | EUR |
|---|---|---|---|---|---|
| | | | (DSITL) | | |
| 0 | 91.16 | 2.38 | 0.00 | 0.00 | 6.46 |
| 1 | 90.60 | 2.61 | 0.00 | 0.00 | 6.79 |
| 12 | 90.12 | 2.94 | 0.02 | 0.04 | 6.89 |
| 24 | 90.12 | 2.94 | 0.02 | 0.04 | 6.89 |
| 35 | 90.12 | 2.94 | 0.02 | 0.04 | 6.89 |
| | | | (JPY) | | |
| 0 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 |
| 1 | 0.01 | 99.59 | 0.01 | 0.39 | 0.00 |
| 12 | 0.16 | 98.71 | 0.16 | 0.84 | 0.12 |
| 24 | 0.16 | 98.71 | 0.16 | 0.84 | 0.12 |
| 35 | 0.16 | 98.71 | 0.16 | 0.84 | 0.12 |
| | | | (USD) | | |
| 0 | 0.00 | 1.57 | 1.72 | 36.59 | 60.12 |
| 1 | 0.96 | 1.68 | 1.57 | 37.61 | 58.18 |
| 12 | 2.31 | 1.73 | 1.53 | 37.75 | 56.68 |
| 24 | 2.31 | 1.73 | 1.53 | 37.75 | 56.68 |
| 35 | 2.31 | 1.73 | 1.53 | 37.75 | 56.68 |
| | | | (GBP) | | |
| 0 | 0.00 | 33.33 | 0.00 | 66.67 | 0.00 |
| 1 | 0.27 | 34.32 | 0.06 | 65.28 | 0.07 |
| 12 | 0.91 | 34.18 | 0.15 | 64.47 | 0.29 |
| 24 | 0.91 | 34.18 | 0.15 | 64.47 | 0.29 |
| 35 | 0.91 | 34.18 | 0.15 | 64.47 | 0.29 |
| | | | (EUR) | | |
| 0 | 0.00 | 26.88 | 0.00 | 0.00 | 73.12 |
| 1 | 0.55 | 25.65 | 0.00 | 0.05 | 73.75 |
| 12 | 1.65 | 24.73 | 0.14 | 0.60 | 72.87 |
| 24 | 1.65 | 24.73 | 0.14 | 0.60 | 72.87 |
| 35 | 1.65 | 24.73 | 0.14 | 0.60 | 72.87 |

Note: Euro substitutes German mark, French franc, Netherlands’ guilder, and Italian lira. Decompositions at each step are given for a “Bernanke” factorization of the innovation correlation/ covariance matrix. The decompositions sum to one hundred in any row. Only SAC-based model results are reported.

[71] All abbreviations and acronyms are provided in Appendix A.

# APPENDIX D

# OLS RESULTS[72]

There are four separate tables attached to this file. The tables represent the OLS regression results that show that for all periods SAC-based models yield significant exposure estimates relative to the models based on local currency. All tables contain three main sections: pre-euro period (1973-1998), euro period (1999-2004), and the total period (1999-2004). Both local currency-based models and SAC-based models are reported for all the periods.

Table 14 represents OLS regression results for daily data on stock market indices and the respective exchange rates for the countries under the study. The results are based on both the local currency model and SAC model for periods 1973-1998 and 1999-2004 respectively. Similarly, Table 15 shows OLS regression results for daily data on stock market indices and the exchange rates for the countries under the study. The results are again based on both local currency model and SAC model for periods 1973-1998 and 1999-2004.

Tables 16 and 17 report OLS regression results for monthly data including both local currency-based models and SAC-based models for periods 1973-1998 and 1999-2004. Table 16 reports regression results of stock market indices and the respective exchange rates, and Table 17 shows regression results of stock market indices and the exchange rates.

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[72] All abbreviations and acronyms are provided in Appendix A.

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