A DYNAMIC FRAMEWORK FOR THE RELATIONS BETWEEN FOREIGN EXCHANGE RATES, SAVINGS AND INVESTMENTS

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ABSTRACT

The Meese-Rogoff forecasting puzzle states that foreign exchange (FX) rates are unpredictable. Since one country's macroeconomic conditions could affect the price of its national currency, we study the dynamic relations between the FX rates and some macroeconomic accounts. Our research tests whether the predictability of the FX rates could be improved through the advanced econometrics. Improving the predictability of the FX rates has important implications for various groups including investors, business entities and the government. The present thesis examines the dynamic relations between the FX rates, savings and investments for a sample of 25 countries from the Organization for Economic Cooperation and Development. We apply quarterly data of FX rates, macroeconomic indices and accounts including the savings and the investments over three decades.

Through preliminary Augmented Dickey-Fuller unit root tests and Johansen cointegration tests, we found that the savings rate and the investment rate are cointegrated with the vector (1,-1). This result is consistent with many previous studies on the savings-investment relations and therefore confirms the validity of the Feldstein-Horioka puzzle. Because of the special cointegrating relation between the savings rate and investment rate, we introduce the savings-investment rate differential (SID). Investigating each country through a vector autoregression (VAR) model, we observe extremely insignificant coefficient estimates of the historical SIDs upon the present FX rates. We also report similar findings through the panel VAR approach. We thus conclude that the historical SIDs are useless in forecasting the FX rate. Nonetheless, the coefficients of the past FX rates upon the current SIDs for both the country-specific and the panel VAR models are statistically significant. Therefore, we conclude that the historical FX rates can conversely predict the SID to some degree. Specifically, depreciation in the domestic currency would cause the increase in the SID.

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TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

CHAPTER I

INTRODUCTION

The unstable movement of the foreign exchange rates remains a major puzzle in international finance. Our study focuses on the predictability of the foreign exchange rates over various horizons. The objective is to test whether the predictability of the foreign exchange rates can be improved upon the random walk model through relying on the recent advances in time series analysis. Our study investigates the dynamic relations between the foreign exchange rate, the savings rate and the investment rate. All of the three variables are assumed endogenous. As the linkage between the latter two and the foreign exchange rate is indirect through current account deficits, we therefore propose to explore their connections with the nominal Trade Balance (TB) account. Other considered macroeconomic factors are the Gross Domestic Product (GDP), the Industrial Production Index (IPI) and the Consumer Price Index (CPI).

Our study contributes to existing literature in the following main aspects. (i) We apply the most up-to-date longitudinal data, including time series data of the foreign exchange rates and the macroeconomic accounts, and the cross-sectional countries from the Organization for Economic Cooperation and Development. (ii) We apply quarterly data to examine the dynamic relations between the foreign exchange rate, the savings rate and the investment rate over various horizons. (iii) Our thesis combines the studies of both the savings-investment relation and the forecasting of the foreign exchange rate, and strives to achieve the latter purpose from the former perspective. (iv) We perform the preliminary unit root and cointegration tests to ensure the authenticity of the data and the applicability of the variables in subsequent model estimations. (v) The vector autoregression (VAR) approaches applied within a panel setting could largely partial out the impacts of cross-sectional heterogeneity.

Managing to forecast the movement of the foreign exchange rate is of substantial interest to various economic entities for several reasons. First, foreign exchange investors interested in the enhanced risk return frontier through international financial or real assets are concerned with the additional exchange risk. Understanding the dynamics behind the latter could help investors manage their risk exposure. Second, macroeconomic policy-makers and authorities from the government would develop better understanding of the consequences of their legal and monetary policies on the domestic currency. Third, managers and executives of multinational corporations in different geographical territories while managing asset costs and revenues labelled in different currencies understand that they are confronted with the foreign exchange risk on top of the basic operational risks. In addition, understanding the foreign exchange risk dynamics has a direct implication on the risk management policy. If one can replicate the inherent foreign exchange rates generating process, one can predict the future trends and volatility levels of the foreign exchange risk exposure.

Nonetheless, literature has recorded that the foreign exchange rates are extremely volatile and unpredictable. The seminal research of Meese and Rogoff (1983) reviewed the forecasting performances of three structural monetary and asset models. The results showed that none of them outperformed the random walk model over the short horizons. Obstfield and Rogoff (2000) referred to the Exchange Rate Disconnect Puzzle (ERDP) as one of the unsolved mysteries in financial economics. Exchange rates are disconnected from the economic reality and seem to be determined outside of the open economy models. For example, the Purchasing Power Parity (PPP) theory that links the exchange rates to the inflation differentials between different economies largely fails when the PPP is tested empirically at various horizons.

We organize the remainder of the thesis as follows: Chapter II reviews existing literature on the savings-investment relations and the foreign exchange rate forecasting methods. In Chapter III we explicate the applied econometric methods of our research. Chapter IV describes the sample selection and the data collection process. Chapter V presents and interprets the empirical findings. In Chapter VI we conclude the thesis and provide further discussions for our study.

CHAPTER II

LITERATURE REVIEW

Since the main objective of the thesis is to test if we could improve the predictability of the foreign exchange rates from the aspect of the savings-investment relation, this chapter reviews numerous previous literature that studies the following research topics: the savings-investment relation, different methods for forecasting the foreign exchange rates, and the interconnection between the savings-investment relation and the prediction of the foreign exchange rates.

2.1. Implications of the Savings-Investment Relation

The relation between domestic savings and investments has important implications upon the degree of international capital mobility. On the one hand, suppose that inhabitants within one country do not have sufficient amount of personal savings; if this country resides in a world where capital is unrestricted to flow across national boundaries, when the government, domestic companies and investors require capital to operate business domestically, they could borrow capital abroad to avoid the risk of being shut down because of the lack of circulation capital. On the other hand, if the residents have considerable savings, controlling for the total amount of domestic investments, corporate entities and investors would select to invest the excess savings abroad. In summary, national savings and domestic investments should be uncorrelated under absolute international capital mobility.

2.2. The Feldstein-Horioka Results

In spite of the proposed assumption in section 2.1, the seminal research of

Feldstein and Horioka (1980) documented contradictory results and found significantly positive correlations between the domestic savings rate and the domestic investment rate for a sample of OECD countries and interpreted this as an implication of imperfect capital mobility. This finding is known as the Feldstein-Horioka puzzle. Various subsequent studies reported similar findings or even stronger savings-investment correlation coefficients using various samples. Some good examples are the Feldstein (1983), Finn (1990), Tesar (1991), Kim (2001), Corbin (2001), Hoffmann (2004) and Bai and Zhang (2010).

The vast majority of the previous studies, however, refused to accept the Feldstein-Horioka results as the indication of low capital mobility by either proposing alternative explanations or reaching different conclusions. Most researchers believe that the demonstration proposed by Feldstein and Horioka misinterprets this world with increasing financial integration and economic globalization. For example, Baxter and Crucini (1993) proved that the positive savings-investment correlation is completely normal through investigating a simple equilibrium model. Eiriksson (2011) applied the similar methodology to a business cycle model and observed the savings-investment correlation which instead resulted from the mutual internal shocks and the similar country sizes. Coakley and Kulasi (1997) attributed the cointegrating relation between the national savings rate and investment rate for eleven developed states to the solvency capabilities of the savings-investment differential. Through model transformations, Murphy (1984) revealed that the assumption that perfect capital mobility would necessarily lead to low savings-investment correlation in the Feldstein and Horioka (1980) is essentially inaccurate and the Feldstein-Horioka test fails to eliminate the impact of country size.

2.3. Contradictory Results to the Feldstein-Horioka Puzzle

A small number of previous studies documented different results from the Feldstein and Horioka (1980) through investigating samples chosen from the industrialized economies. For instance, using annual data to partial out the impacts of the intertemporal budget constraint and the country effects, Krol (1996) reported significantly lower saving retention coefficients for a group of countries similar as those OECD countries in the Feldstein and Horioka (1980) and concluded that capital mobility is indeed high.

Many studies failed to find the Feldstein-Horioka results for samples selected from the less developed countries. For example, Vamvakidis and Wacziarg (1998) found that the positive savings-investment correlation disappeared and the saving retention coefficients were significantly lower for any non-OECD samples. Moreover, Holmes (2005) reported a saving retention coefficient of approximately 30% for a group of developing countries through applying the same Feldstein-Horioka panel regression approach.

2.4. Connection between the Savings-Investment Relation and the Foreign Exchange Rate

Despite the large number of the aforementioned studies, very few have linked the savings-investment relation with the contemporaneous foreign exchange rates. Turner (1988) pioneered the studies upon the interconnection between the foreign exchange rates and macroeconomic variables, and found that the domestic savings-investment differentials are significantly subject to the foreign exchange rates for the three largest economies: United States, Japan and Germany. A more noticeable study is the Frankel (1988), which reasoned the volatile feature of the foreign exchange rates from the perspective of the savings-investment relations in the United States, and the transnational interest rates between the United States and the United Kingdom. He established four interdependent explanations for the perfect capital mobility and concluded that the Feldstein-Horioka findings could result from the untenable real interest parity.

2.5. Foreign Exchange Rate Forecasting Methods

Various previous studies have developed different methods and models to improve the predictability of the foreign exchange rates. We explain the following five methods for forecasting the foreign exchange rates and compare their performances.

2.5.1. Forward Exchange Rate Prediction

The most fundamental ideology for applying the forward exchange rate to forecast the future spot exchange rate is assuming that the expectations of the future exchange rates equal the forward exchange rates. Nonetheless, most literature has reported the inaccurate predicting performance of the forward prediction. For instance, Agmon and Amihud (1981) documented the disappointing performance of the forward forecasting and that the forward prediction was surpassed by the current-time exchange rate prediction over various horizons. Fama (1984) verified that the statistical power of the forward prediction is very low even though this method was assumed efficient. Furthermore, Aggarwal, Lucey and Mohanty (2009) adopted several data-adjusting and testing procedures. They found that forward estimators were both inefficient and inconsistent, and thus negated the unbiased performance of the forward prediction.

Moreover, only under the hypothesis of "simple market efficiency" when there are no arbitrage opportunities in the forward exchange markets could the forward exchange rates consistently estimate the expectations of the future exchange rates. This theory becomes problematic since numerous former studies have documented forceful evidences against the simple market efficiency hypothesis. These studies include Hansen and Hodrick (1980), Hsieh (1984), and Lai and Lai (1991).

2.5.2. Random Walk Model and Martingale Hypothesis

Literature concerning the tests for the null hypothesis of martingale in time series foreign exchange rates has reported various results. Yang, Su and Kolari (2008) failed to reject the null hypothesis of martingale for daily Euro exchange rates over six years. Using daily data of eight currencies over almost sixteen years in Australia and Asia, Al-Khazali, Pyun and Kim (2012) verified the properties of the martingale difference sequence and the random walk for the exchange rates of three currencies and rejected the properties for the rest five currencies. An intriguing finding is that both the McCurdy and Morgan (1987, 1988) rejected the martingale hypothesis for daily Euro exchange rates and failed to reject the hypothesis for weekly data.

The random walk model has gained popularity since the seminal research of the Meese and Rogoff (1983a). Numerous subsequent studies have reported this puzzling result. Some examples are the Meese and Rogoff (1983b, 1985), Wolff (1988), Diebold and Nason (1990), Mizrach (1992), Engle (1994) and Qi and Wu (2003). Some studies declared that the statistical properties of the foreign exchange rates inherently determined their random walk behavior. Hsieh (1988) found that the statistical distributions of daily foreign exchange rates of five currencies are significantly time-variant. Hsieh (1989) rejected the null hypothesis of Gaussian distribution for all the tested currencies. Choi (1999) applied monthly foreign exchange rates over three decades and rejected the null hypothesis of the random walk for only one currency. Recent literature, including Belaire-Franch and Opong (2005) and Chortareas, Jiang and Nankervis (2011), has documented similar findings.

2.5.3. Frenkel-Bilson Flexible Price Monetary Model

The Flexible Price Monetary Model claims that the foreign exchange rate is the relative price of two currencies rather than that of two identical consumption bundles between two countries. For example, Frenkel wrote in his 1976 paper that "It is reasonable, therefore, that a theory of the determination of the relative price of two moneys could be stated conveniently in terms of the supply of and the demand for these moneys." Bilson (1978) supported Frenkel's viewpoint by stating that the foreign exchange rate is the solution to the product between the ratio of two countries' money supplies and the ratio of two countries' real money balance demands. The model demonstrates that the level of the foreign exchange rate is determined by the supply and demand levels of the money market.

The main problem regarding this model is that the model assumes the consistent standing of the Purchasing Power Parity (PPP). However, much literature has affirmed that the PPP fails to hold over the short horizons. To conclude, because the same commodity is given variant values by people from different countries, declaring that the exchange rates will eventually shift towards the relative price between two identical consumption bundles is unrealistic.

2.5.4. Dornbusch-Frankel Sticky Price Monetary Model

Dornbusch (1976) and Frankel (1979) claimed that the Frenkel-Bilson model is based on a vulnerable foundation. Dornbusch and Frankel reasoned that there is a substantial disparity between the adjusting speed of the commodity market and that of the capital market when both markets are faced with the same external shocks. Therefore, the PPP fails to hold in the short run. Because of the inherent features of the commodity market and the lack of timely and precise information, the commodity market requires considerably more time than the capital market to adjust the prices and reach a new equilibrium. These prices are termed the "sticky prices". Thus, the PPP is indeed feasible in the longer horizons. This model instead demands the consistent realization of the Uncovered Interest Rate Parity (UIRP).

2.5.5. Hooper-Morton Sticky Price Asset Model

Hooper and Morton (1982) adopted the methodology developed in the Dornbusch (1976) and the Frankel (1979), and introduced extra independent variables to the model. These variables are the time series variation of real foreign exchange rate, the time series variation of current account balance, the cross sectional variation of exchange risk premium and the difference of cross sectional inflation rate. Hooper and Morton believe that assuming the same level of inflation within two countries is unreasonable and the long-term current account condition should count as a crucial factor that affects the movement of the foreign exchange rates. Nevertheless, the literature has documented that the Hooper-Morton model failed to make substantial differences from the Dornbusch-Frankel model since the model accomplished nothing whatsoever to remove the assumption of the UIRP.

CHAPTER III

ECONOMETRIC FRAMEWORK

According to the order where we perform the specific tests and estimate the models, we present the methodology for our research in this chapter. We perform two preliminary tests, the unit root test and the cointegration test upon the collected data. Afterwards, we estimate different models and perform the specification tests to ensure the robustness of our results.

3.1. Preliminary Statistical Tests

Unit root exists largely in various macroeconomic and financial time series variables. Hence, we perform the Augmented Dickey-Fuller (ADF) unit root test upon the variables of our interest in the first place. The Johansen cointegration test is then applied to specific combinations of non-stationary variables. The cointegration test allows us to explore the possibility for forecasting the foreign exchange rate through investigating the long term cointegrating relations among the variables and proceed with the model estimations. We specify the test rationales and procedures below.

3.1.1. Augmented Dickey-Fuller Unit Root Test

Dickey and Fuller (1979) developed the conventional Dickey-Fuller unit root test to test for the existence of the unit root for a univariate time series. Let us assume the stochastic process of our interest y_t and the simple autoregressive model represented by equation (1):

$$y_t = \omega y_{t-1} + \varepsilon_t \qquad (1)$$

Where t represents the time series identifier, ω estimates the coefficient of our interest and ε_t denotes the random error term. The process y_t is defined to have the feature of the unit root if $\omega = 1$ in the equation (1). This autoregressive model was then transformed to the model represented in equation (2):

$$\Delta y_t = (\omega - 1) y_{t-1} + \varepsilon_t = \theta y_{t-1} + \varepsilon_t \qquad (2)$$

Therefore, testing the null hypothesis of unit root for y_t is similar as testing whether $\theta = 0$ in the equation (2). This is the fundamental conception of the Dickey-Fuller unit root test. Afterwards, the Dickey-Fuller test was expanded to the Augmented Dickey-Fuller (ADF) test to accommodate more complicated systems of autoregressive models including the following one represented by equation (3):

$$\Delta y_t = c + \rho t + \theta y_{t-1} + \lambda_1 \Delta y_{t-1} + \lambda_2 \Delta y_{t-2} + \cdots + \lambda_p \Delta y_{t-p} + \varepsilon_t \qquad (3)$$

If the coefficient θ is not statistically different from zero in the equation (3), there exists a unit root in y_t. This is the foundation for the ADF unit root test.

Compared with the Dickey-Fuller test, the ADF unit root test allows for more lagged series of the tested variables and significantly improves the statistical power. The ADF test also allows for larger samples. In our research, since we indeed study a large sample of hundreds of observations and require more lags of the endogenous variables for estimating the vector autoregression models, we apply the ADF test instead of the Dickey-Fuller test in the analysis.

3.1.2. Augmented Dickey-Fuller Unit Root Test Specification

We perform the Augmented Dickey-Fuller unit root test on a univariate basis. To investigate the property of stationarity for the variables of our interest, we conduct the ADF test upon each of the following variables and afterwards differentiate the non-stationary variables from the stationary variables to continue the cointegration tests:

(i) Foreign Exchange (FX) Rate

The FX rates are the exchange ratios between different currencies. There are various types of foreign exchange rates according to different classification schemes. For example, based on the business hours of the foreign exchange markets, the FX rates include the opening price, the average price, the closing price and any real-time spot price. In the present thesis we select the closing prices for the FX rates.

(ii) Nominal Trade Balance Ratio (TBR)

The TBR represents the nominal trade balance ratio. It is expressed as the ratio of the nominal trade balance with respect to the nominal Gross Domestic Product (NGDP). The nominal trade balance is among the most important components of a country's current account.

(iii) Savings Rate (SR)

The SR stands for the percentage of the gross national savings (GNS) to the NGDP. In addition, the GNS is a major component of the NGDP. Since there are significant differences among the savings rates of different countries, the SR leaves direct implications upon comparing the relative preferences of personal savings of inhabitants within different countries.

(iv) Investment Rate (IR)

The IR represents the percentage of the gross capital formations (GCF) to the NGDP. The investment, along with the consumption and the net exports, are the three major motivators of a country's Gross Domestic Product (GDP). Similarly, there exists considerable disparities among the levels of investments within different countries, and therefore, the IR could reflect the investment propensity for residents within different countries.

(v) Savings-Investment Rate Differential (SID)

The SID is the numerical difference between the SR and the IR. Depending on their relative values, the SID could be either positive or negative, and could reflect the current account condition of a country to some extent.

(vi) Difference in Logarithm of the Foreign Exchange Rate (FXC)

We calculate the FXC by taking the first order difference between the logarithm in the level FX rate and the logarithm of the first lagged time series of the FX rate. We could directly measure the volatility of the foreign exchange rate by investigating the pattern of the FXC.

(vii) Difference in Logarithm of the Consumer Price Index (CPIC)

We derive the CPIC by taking the first order difference between the logarithm of the level consumer price index (CPI) and the logarithm of the first lagged time series of the CPI. Under the majority of circumstances, there is a linear trend in the level CPI and thus we perform the ADF test upon the CPIC instead of the CPI.

(viii) Difference in Logarithm of the Industrial Production Index (IPC)

Similarly, we calculate the IPC through the first order difference between the logarithm of the level industrial production index (IPI) and the logarithm of the first lagged time series of the IPI. Usually there is a strong positive correlation between the IPI and the NGDP. Therefore, the level IPI would demonstrate an obvious linear upward trend since we include a significantly large number of time series observations in the panel. Therefore, we choose to test for the unit root in the IPC.

(ix) Difference in Logarithm of the Real Gross Domestic Product (RGDPC)

When the economy is operating well, the amount of the Real Gross Domestic Product (RGDP) is growing at a relatively stable speed. This trend stationarity of the RGDP becomes obvious especially when the country experiences a long term economic prosperity. We thus derive the RGDPC by calculating the first order difference between the logarithm of the level RGDP and the logarithm of the first lagged time series of the RGDP, and perform the unit root test upon the RGDPC.

3.1.3. Johansen Cointegration Test

The Johansen test investigates the cointegrating relations among multiple time series variables. To perform the test, all the variables of interest must be non-stationary in the first place. We perform the test to observe whether a group of variables are cointegrated and whether there exists a long term cointegrating vector.

Our purpose is to find their linear combination that could generate a stationary process.

In our study, the principal variable of interest is the foreign exchange rate. Thus, we will test for cointegrating relations between the foreign exchange rate and other variables if the foreign exchange rate is non-stationary. The savings rate and the investment rate are also our focused variables because we will revisit the validity of the Feldstein-Horioka puzzle. We achieve this goal through testing for cointegration between the savings rate and the investment rate. Since the Johansen cointegration test allows for multivariate cointegrating relations and there exits indeed one combination of three time series variables in our research, we apply the Johansen system instead of the Engle-Granger (1987) method.

3.1.4. Johansen Cointegration Test Specification

After we report the ADF test results, we choose to conduct the cointegration tests among the non-stationary variables. We perform the test by considering all the four linear test specifications:

(i) No deterministic trend in the data; no intercept or trend in the cointegrating equations,

(ii) No deterministic trend in the data; an intercept but no trend in the cointegrating equations,

(iii) Linear trend in the data; an intercept but no trend in the cointegrating equations,

(iv) Linear trend in the data; both an intercept and a trend in the cointegrating equations.

The Johansen test is performed with both the trace test and the eigenvalue test. We assume that the number of cointegrating vectors is r and the number of tested variables is k for each combination. The null hypothesis is ($r \leq k$) for the trace test and ($r = k$) for the eigenvalue test. We compare r with k and summarize the results. We select 4 lags for the tested variables to cover one whole year. We perform the

Johansen cointegration test upon each of the following combinations of variables:

(i) Foreign Exchange Rate versus Savings Rate

(ii) Foreign Exchange Rate versus Investment Rate

(iii) Foreign Exchange Rate versus Investment Rate versus Savings Rate

(iv) Foreign Exchange Rate versus Savings-Investment Rate Differential

(v) Foreign Exchange Rate versus Nominal Trade Balance Ratio

(vi) Investment Rate versus Savings Rate

Among the seven tested variable combinations, we would concentrate on those combinations that contain the foreign exchange rate. These combinations are the numbers (i), (ii), (iii), (iv) and (v). Number (vi) testing for cointegration between the savings rate and the investment rate could enable us to revisit the Feldstein-Horioka results. After we report the test results, we organize the combinations of variables with cointegrating relations and the error correction models could then be estimated upon these cointegrated variables.

3.2. Econometric Models

Dynamic modeling has been generally applied in many research areas, especially financial analyses and macroeconomic forecasting. After we complete the preliminary tests for the variables, we estimate the following dynamic models to obtain our empirical results.

3.2.1. Error Correction Model Specification

After we complete the preliminary tests, assuming that the Feldstein-Horioka puzzle is still valid, we would expect that the cointegrating vector of the savings-investment rate pair is (1,-1). The difference between the savings rate and the investment rate could then be applied to forecast the foreign exchange rates. If the foreign exchange rate is cointegrated with the savings rate and the investment rate, there exists a long term linear combination of the three variables that would generate a stationary process.

Therefore, the Error Correction Models (ECMs) could be implemented. We will also perform tests of the foreign exchange rate to stimuli for either the savings rate or the investment rate. The latter tests for not only the predictability of the foreign exchange rate but the effectiveness of monetary policies on the price of the domestic currency. However, we are mostly interested in how the foreign exchange rates react to deviations between the savings rate and the investment rate. The ECMs are specified as:

$$\begin{cases} \Delta FX_{i,t} = d_1 + \alpha_1 \Delta FX_{i,t-1} + \cdots + \alpha_p \Delta FX_{i,t-p} + \beta_1 \Delta IR_{i,t-1} + \cdots + \beta_p \Delta IR_{i,t-p} + \gamma_1 \Delta SR_{i,t-1} \\ + \cdots + \gamma_p \Delta SR_{i,t-p} + \lambda_1 TBR_{i,t-1} + \mu_1 RGDPC_{i,t-1} + \rho_1 CPIC_{i,t-1} + \eta_1 IPC_{i,t-1} \qquad (4) \\ - \delta_1 (FX_{i,t-1} - a - bSR_{i,t-1} - cIR_{i,t-1}) + \xi_{i,t}^1 \\ \\ \Delta SR_{i,t} = d_2 + \phi_1 \Delta FX_{i,t-1} + \cdots + \phi_p \Delta FX_{i,t-p} + \theta_1 \Delta IR_{i,t-1} + \cdots + \theta_p \Delta IR_{i,t-p} + \omega_1 \Delta SR_{i,t-1} \\ + \cdots + \omega_p \Delta SR_{i,t-p} + \lambda_2 TBR_{i,t-1} + \mu_2 RGDPC_{i,t-1} + \rho_2 CPIC_{i,t-1} + \eta_2 IPC_{i,t-1} \qquad (5) \\ - \delta_2 (FX_{i,t-1} - a - bSR_{i,t-1} - cIR_{i,t-1}) + \xi_{i,t}^2 \\ \\ \Delta IR_{i,t} = d_3 + \psi_1 \Delta FX_{i,t-1} + \cdots + \psi_p \Delta FX_{i,t-p} + \kappa_1 \Delta IR_{i,t-1} + \cdots + \kappa_p \Delta IR_{i,t-p} + \tau_1 \Delta SR_{i,t-1} \\ + \cdots + \tau_p \Delta SR_{i,t-p} + \lambda_3 TBR_{i,t-1} + \mu_3 RGDPC_{i,t-1} + \rho_3 CPIC_{i,t-1} + \eta_3 IPC_{i,t-1} \qquad (6) \\ - \delta_3 (FX_{i,t-1} - a - bSR_{i,t-1} - cIR_{i,t-1}) + \xi_{i,t}^3 \end{cases}$$

Where t is the time series identifier;

i is the cross section identifier; i=1, 2, 3,⋯, 25 and corresponds to the countries listed in table 1.

We assume that $FX_{i,t} = a + bSR_{i,t} + cIR_{i,t}$ is the long term cointergrating relation among the FX rate, SR and IR; δ_1, δ_2 and δ_3 stand for the error correction parameters that measure how each dependent variable reacts to deviations of the other independent variables (with lag difference operators).

The applicability of the ECMs depends exclusively on the Johansen cointegration test results. Since the FX rate is the focused variable in our study, we will primarily concentrate on those combinations of cointegrated variables that include the FX rate. If there is no cointegrating relations that involve the FX rate, estimations of the ECMs will be unnecessary.

3.2.2. Univariate Vector Autoregression Model Specification

As interpreted in section 5.3, only the Savings Rate (SR) and the Investment Rate (IR) are cointegrated with the vector (1,-1). We hence estimate the Vector Autoregression (VAR) models with the Foreign Exchange (FX) rate and the Savings-Investment Rate Differential (SID) as the two endogenous variables. The SID is the numerical difference between the SR and the IR. We test for the lead lag relations for the FX rate and the SID. We estimate the VAR model for each cross section separately. The specific VAR models are:

$$\begin{cases} FX_{i,t} = c_i + \alpha_{i,1}FX_{i,t-1} + \alpha_{i,2}FX_{i,t-2} + \cdots + \alpha_{i,p}FX_{i,t-p} + \beta_{i,1}SID_{i,t-1} + \beta_{i,2}SID_{i,t-2} + \cdots + \beta_{i,p}SID_{i,t-p} \\ \quad + \lambda_i^{fx}TBR_{i,t-1} + \mu_i^{fx}RGDPC_{i,t-1} + \rho_i^{fx}CPIC_{i,t-1} + \eta_i^{fx}IPC_{i,t-1} + e_{i,t}^1 \qquad (7) \\ \\ SID_{i,t} = d_i + \varphi_{i,1}FX_{i,t-1} + \varphi_{i,2}FX_{i,t-2} + \cdots + \varphi_{i,p}FX_{i,t-p} + \theta_{i,1}SID_{i,t-1} + \theta_{i,2}SID_{i,t-2} + \cdots + \theta_{i,p}SID_{i,t-p} \\ \quad + \lambda_i^{sid}TBR_{i,t-1} + \mu_i^{sid}RGDPC_{i,t-1} + \rho_i^{sid}CPIC_{i,t-1} + \eta_i^{sid}IPC_{i,t-1} + e_{i,t}^2 \qquad (8) \end{cases}$$

Where t represents the time series identifier;

i is the cross section identifier; i=1, 2, 3,⋯, 25 and corresponds to the countries listed in table 1.

According to the Akaike Information Criterion (AIC), the numbers of lags p for the FX rate and the SID are different for different cross sections.

We apply various specifications to estimate the model and summarize the findings.

These specifications differ from each other in that we specify different combinations of the exogenous variables to include in the estimations. The four exogenous variables in the models are the nominal trade balance ratio (TBR), the difference in logarithm of the real Gross Domestic Product (RGDPC), the difference in logarithm of the consumer price index (CPIC) and the difference in logarithm of the industrial production index (IPC). We thus manage to observe and compare the performances of the explanatory variables for different specifications. The estimation method is the ordinary least squares. We test the bilateral effects of the FX rate and the SID upon each other through studying the statistical significance of the coefficient estimates of the lagged endogenous variables. We also investigate the impulse response functions and the variance decompositions for the dependent variables, and summarize the results.

3.2.3. Panel Vector Autoregression Model Specification

After we estimate the VAR models for all the cross sections, we study our sample countries through a panel approach as in Coiteux and Oliver (2000). Panel data approach coupled with the VAR could test whether the same restriction applies to different countries, including the economy size effect. Relying on the Schwarz Information Criterion (SIC), we choose the first and the second lagged time series of the endogenous variables as the explanatory variables. Moreover, we assume that the individual effect is correlated with the regressors in our model and cross section fixed effects exist. The fixed effects are assumed time-invariant. Therefore, we conduct the panel VAR approach with or without fixed effects, and compare their performances afterwards. We create 24 cross sectional dummy variables $DV_1, DV_2, DV_3, ..., DV_{24}$ to denote the individual-specific fixed effects. An additive constant c is included in both equations. Eventually, we conduct the panel VAR formally as:

$$FX_{i,t} = \alpha_1 FX_{i,t-1} + \alpha_2 FX_{i,t-2} + \beta_1 SID_{i,t-1} + \beta_2 SID_{i,t-2} + \lambda_1 TBR_{i,t-1} + \mu_1 RGDPC_{i,t-1} + \rho_1 CPIC_{i,t-1} + \eta_1 IPC_{i,t-1} + c_1 + f_1^{fx} DV_1 + f_2^{fx} DV_2 + \cdots + f_{24}^{fx} DV_{24} + \varepsilon_{i,t}^{fx} \quad (9)$$

$$SID_{i,t} = \gamma_1 FX_{i,t-1} + \gamma_2 FX_{i,t-2} + \theta_1 SID_{i,t-1} + \theta_2 SID_{i,t-2} + \lambda_2 TBR_{i,t-1} + \mu_2 RGDPC_{i,t-1} + \rho_2 CPIC_{i,t-1} + \eta_2 IPC_{i,t-1} + c_2 + f_1^{sid} DV_1 + f_2^{sid} DV_2 + \cdots + f_{24}^{sid} DV_{24} + \varepsilon_{i,t}^{sid} \quad (10)$$

Where *t* represents the time series identifier;

i represents the cross section identifier; *i*=1, 2, 3,⋯, 25 and corresponds to the countries in table 1.

We distinguish the fixed effects of different countries through the coefficients f_1^{fx} to f_{24}^{fx} and f_1^{sid} to f_{24}^{sid} before the dummies in the equations. The DV_i consists of ones for the i^{th} cross section and zeroes for other cross sections.

Applying the similar approach as in section 3.2.2, we choose several different specifications to estimate the model and compare the results. Superior to the univariate VAR model, the multivariate VAR estimations enable us to decide whether to include the cross section fixed effects. The method for estimating the model is the two stage least squares. The first stage regression involves the conventional Ordinary Least Squares (OLS) and the estimates are obtained as:

$$\hat{\beta}_1 = (X'X)^{-1} X'Y \quad (11)$$

Where Y is a column vector of the endogenous variable, the FX or the SID rate; X is the regressor matrix. We assume that the error terms in the model are strongly heteroscedastic. Therefore, we apply the White corrections [1] to the variance covariance matrices of the residuals of the OLS regression. We generate the Omega (Ω) matrices by replacing the diagonal elements of each cross section with the variances of the residuals of each cross section with the adjusted degrees of freedom.

1 The White's Heteroscedasticity Consistent (HC) estimators only correct heteroscedasticity in the errors. Autocorrelation of the errors is assumed non-existent for HC estimators. Our panel regression approach largely partials out the necessity of the assumption of autocorrelation.

All the off-diagonal entries are zeroes. And we perform the second stage regression with the White corrections as:

$$\hat{\beta}_2 = (X'\Omega^{-1}X)^{-1}X'\Omega^{-1}Y \tag{12}$$

After running the regressions, we report the time-invariant coefficient estimates for all the cross sections and thus manage to evaluate the effects of different predictor variables on improving the predictability of the foreign exchange rates in a panel setting. In addition, according to the estimation results, we impose one standard deviation to the error terms ε^{fx} and ε^{sid} in the equations (9) and (10) respectively at time 0, plot and observe the impulse response functions of the FX rate and the SID. The impulse response function approach would contribute to verifying the model estimation results.

3.3. Specification Test for Fixed Effects

After we obtain the multivariate VAR estimates, we test for the existence of cross section fixed effects. To achieve this purpose, we need to choose among the model specifications where the cross section fixed effects are considered in the estimations in section 3.2.3. We test whether the coefficient estimates for all the 24 cross sectional dummies are equal. The hypotheses are formulated as:

$$\begin{cases} H_0: \ \hat{f}_1^{fx} = \hat{f}_2^{fx} = \cdots = \hat{f}_{24}^{fx} \\ H_A: \ \text{Any one pair is unequal.} \end{cases} \tag{13}$$

$$\begin{cases} H_0: \ \hat{f}_1^{sid} = \hat{f}_2^{sid} = \cdots = \hat{f}_{24}^{sid} \\ H_A: \ \text{Any one pair is unequal.} \end{cases} \tag{14}$$

The applied test is the Wald test for restrictions. We calculate the test statistic through the following formula:

$$W = \frac{(R'\hat{\beta})'[R'(X'\Omega^{-1}X)^{-1}R](R'\hat{\beta})}{J} \tag{15}$$

We assume that the errors ε^{fx} and ε^{sid} in the equations (9) and (10) are normally distributed. The Wald statistics will be distributed according to the F-distribution with *J*, (*n*-*k*) degrees of freedom. Here *J* is the number of restrictions; (*n*-*k*) is the difference between the number of observations *n* and the number of coefficient estimates *k*. The restriction matrix *R* consists of 24 columns. We construct *R* by stacking two matrices: a [(*k*-24) by 24] matrix full of zeroes and an identity matrix of (24 by 24). By comparing the test statistics with the corresponding critical values, we determine whether the cross section fixed effects exist in our panel.

CHAPTER IV

SAMPLE AND DATA

This chapter specifically describes the sample selection and the data collection process in our study. We explain the reasons for selecting our sample and present all the sample countries. In addition, we present the data sources for the variables and explain how they are derived. Finally, we perform several preliminary transformations upon the collected data to obtain the variables in our econometric models.

4.1. Sample Selection

We select countries from the Organization for Economic Cooperation and Development (OECD) as our sample for the following main reasons. First, considering numerous relevant previous studies were focused on the OECD, we will make our findings comparable to theirs. Second, the vast majority of the OECD members are among the most advanced economies in the world, and their time series data would be the most reliable and available of the frequency we require. Third, the foreign exchange markets in the OECD countries are the most dynamic, floating and diversified, and we need data of floating rather than fixed foreign exchange rates to conduct our research. We will also focus on some countries with the most floating foreign exchange schemes. Finally, the seminal study of the Feldstein and Horioka (1980) conducted analyses exclusively upon the OECD and we will revisit the Feldstein-Horioka results by considering the OECD as well.

At present, there are 34 members in the OECD. Five of them joined the OECD very recently (mostly after 2010) and hence, we have deleted them from the sample. They include Chile, Estonia, Israel, Slovak Republic and Slovenia. Four of them provide insufficient observations in the VAR models and thus we deleted them as well.

They include Ireland, Luxembourg, Portugal and Spain. Therefore, a total of 25 countries remain in our research. They include Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Italy, Japan, Korea (Republic of), Mexico, Netherlands, New Zealand, Norway, Poland, Sweden, Switzerland, Turkey, the United Kingdom and the United States of America. Table 1 shows the cross section identifier for each in the analysis.

[Please insert Table 1 about here.]

4.2. Data Description

The time series data of different cross sections constitute an unbalance panel in our research. The numbers of time series observations vary across different countries. The maximum sample period is from the first quarter of 1950 to the second quarter of 2013. For the subsequent VAR model estimations and regression analyses, we remove all the time series observations with missing values and construct a balanced panel. The sample period of most countries in the balanced panel is from the first quarter of 1980 to the second quarter of 2013. We describe our data through the following three aspects: the data sources for all the variables, data of those variables applied to derive the endogenous variables, and data of those variables applied to derive the exogenous variables in our vector autoregression models.

4.2.1. Data Sources

Despite the substantial former research on forecasting the foreign exchange rate, few studies have connected the foreign exchange rate with the relevant macroeconomic variables. In our study, we strive to improve the predictability of the foreign exchange rates through investigating the interdependent relations between the foreign exchange rate and those exogenous variables. Therefore we collect the data for various macroeconomic indices. The data sources for the variables are reported in table 2.

[Please insert Table 2 about here.]

We collect the time series data of most macroeconomic indices, including the Gross National Savings (GNS), the nominal Gross Domestic Product (NGDP), the nominal Gross Domestic Product Deflator (NGDPdeflator), the total Exports of goods and services as a percentage of the nominal Gross Domestic Product (ExportR), the total Imports of goods and services as a percentage of the nominal Gross Domestic Product (ImportR) and the Consumer Price Index (CPI) from the source of the *Oxford Economics*[2] on DataStream. For the Foreign Exchange (FX) Rate and the Industrial Production Index (IPI), we collect them respectively from the sources of the *Oxford Economics* and the International Monetary Fund *World Economic Outlook* on Bloomberg Terminal. We collect the vast majority of the Gross Capital Formations (GCFs) from the *OECD Quarterly National Accounts* on the OECD official website.

4.2.2. Variables

As interpreted in the Chapter III, the foreign exchange (FX) rate and the savings-investment rate differential (SID) are the two endogenous and most important variables in the vector autoregression models. We specify the originally collected variables relevant to the derivation of the FX rate and the SID in this section.

(i) Foreign Exchange Rate:

We collect the foreign exchange (FX) rates as the closing spot rates and on the end date of each quarter. We gather the units of the 25 currencies required to purchase one unit of the United States dollar (USD). These 25 currencies and their three-digit codes from the International Organization for Standardization (ISO) are respectively:

2 *Oxford Economics* was cofounded with the University of Oxford in 1981. Currently it is one of the most successful business and economic data providers. Its macroeconomic and financial data cover more than 190 countries and multiple time series. The data are especially useful for economical modeling, consulting and forecasting.

Australian dollar (AUD), Austrian schilling (ATS), Belgian franc (BEF), Canadian dollar (CAD), Czech koruna (CZK), Danish krone (DKK), Finnish markka (FIM), French franc (FRF), German mark (DEM), Greek drachma (GRD), Hungarian forint (HUF), Icelandic krona (ISK), Italian lira (ITL), Japanese yen (JPY), Korean won (KRW), Mexican peso (MXN), Dutch guilder (NLG), New Zealand dollar (NZD), Norwegian krone (NOK), Polish zloty (PLN), Swedish krona (SEK), Swiss franc (CHF), Turkish lira (TRY), British pound (GBP) and the Euro (EUR)[3].

Eight countries are the Eurozone[4] members and therefore, the data of the foreign exchange rates of their original currencies after 2002 are inapplicable. These countries include Austria, Belgium, Finland, France, Germany, Greece, Italy and the Netherlands. They have shared the Euro since the first quarter of 2002.

(ii) Gross National Savings:

We collect the gross national savings (GNS) in local currencies. The GNS is derived by summing the savings from all the sectors and units, and the GNS is equivalent to the gross national income less the final consumption expenditure for a specified group of residents.

(iii) Gross Capital Formation:

We collect the gross capital formation (GCF) in local currencies. The GCF is previously recognized as the gross domestic investment. The GCF is derived by summing the Gross Fixed Capital Formation (GFCF) and net changes in the level of inventories within a specified geographical dimension.

(iv) Nominal Gross Domestic Product:

We collect the nominal Gross Domestic Product (NGDP) in local currencies, the NGDP reflects the total value of all the goods and services produced within one

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3 The Euro currency was officially initiated on January 1, 1999. It debuted on the international financial market on January 4, 1999. On January 1, 2002, the Euro banknotes and coins entered the market and became the circulation currency. On February 28, 2002, the national currencies of Eurozone members completely exited circulative domain. The three-year coexisting period of the Euro currency and Eurozone members' original currencies was eventually over.

4 The original currencies and the Euro will be analyzed separately for the 8 countries. In this study, we apply the data for Euro only from 2002. Any foreign exchange rate data applied for these 8 Eurozone member countries before 2002 stems from the original currency.

country during a specific fiscal period. We will apply the NGDP to calculate the rates and ratios for several macroeconomic indices. Moreover, the growth rate of the NGDP will serve as a predictor variable in the vector autoregression models.

Since we have to select among the four exogenous variables, the nominal trade balance ratio (TBR), the difference in logarithm of the real Gross Domestic Product (RGDPC), the difference in logarithm of the consumer price index (CPIC) and the difference in logarithm of the industrial production index (IPC) for estimating the error correction models and the vector autoregression models, we explicate the collected data relevant to deriving these four variables below.

(v) Nominal Gross Domestic Product Deflator:

The nominal Gross Domestic Product deflators measure the level of inflation for the three most important components of the nominal Gross Domestic Product, the investment, the consumption and the net exports. In the present thesis we collect them as the price indices and the base year for all the cross sections is 2005 (the price index in 2005 is equal to 100).

(vi) Total Exports of Goods and Services, as a percentage of the nominal Gross Domestic Product:

The total exports of a country are the total value of the exportations of goods and services from all the domestic societal sectors to foreign countries. We notated the total value of the exports of goods and services, as a percentage of the nominal Gross Domestic Product as "ExportR" hereafter in the thesis.

(vii) Total Imports of Goods and Services, as a percentage of the nominal Gross Domestic Product:

The total imports of a country measure the total value of the importations of foreign goods and services regardless of the sectors. We similarly notate the total imports of goods and services, as a percentage of the nominal Gross Domestic Product as "ImportR" hereafter in the thesis.

(viii) Consumer Price Index:

We collect the consumer price index (CPI) as the price index. The CPI measures the level of inflation in the consumption prices of a relatively fixed consumption bundle. There does not exist a base year for all the cross sections in the originally gathered CPIs, but we will transform the CPIs into the time-variant differences of logarithm later and set one certain year as the base.

(ix) Industrial Production Index:

The industrial product index (IPI) is a direct benchmark to measure the total value of a country's real production output from different manufacturing sectors. In our study we collect the IPI as the price index and the base year for all the countries is 2005 (the price index in 2005 is equal to 100).

4.3. Preliminary Transformations of the Data

To derive the variables in the error correction models and the vector autogression models, and directly perform the model estimation approaches, we apply the following transformations upon the gathered data:

(i) Many time series macroeconomic variables are expressed in different units when downloaded the original databases. We transform the units of all the relevant macroeconomic data into the billions of local currencies for unification purposes.

(ii) In our thesis, we need to adjust the level of inflation with respect to the Gross Domestic Product (GDP) before applying the GDPs in the analyses. Therefore, we transform the nominal Gross Domestic Product (NGDP) into the real Gross Domestic Product (RGDP) via the NGDP deflator (NGDPdeflator) through the following formula:

$$RGDP = NGDP \times \frac{100}{NGDPdeflator} \tag{16}$$

(iii) Since one country's nominal trade balance is the difference between the total exports and the total imports in the current account, we derive the nominal Trade Balance Ratio (TBR, the nominal Trade Balance as a percentage of the nominal Gross Domestic Product) by subtracting the *ImportR* from the *ExportR* defined in section 4.2.3:

$$TBR = ExportR - ImportR \tag{17}$$

(iv) Under the majority of circumstances, the aggregate amount of a country's Gross National Savings (GNS) is growing and there exists a trend. Applying them directly in the model analyses would be inappropriate. Thus, we divide the GNSs by the NGDPs to derive their rates and this new variable is the Savings Rate (SR) hereafter in the thesis:

$$SR = \frac{GNS}{NGDP} \times 100 \tag{18}$$

(v) Similarly as the GNS, the total value of a country's Gross Capital Formations (GCF) is increasing when the economy is functioning under normal circumstances and there is a time series trend. The percentage of the GCFs with respect to the nominal Gross Domestic Products is the Investment Rate (IR) hereafter in the thesis:

$$IR = \frac{GCF}{NGDP} \times 100 \tag{19}$$

(vi) Since we verified that the savings rate and the investment rate are cointegrated with the vector (1,-1), we introduce the Savings-Investment Rate Differential (SID) through subtracting the IR from the SR and include the SID in the model estimations:

$$SID = SR - IR \tag{20}$$

CHAPTER V

EMPIRICAL RESULTS

We present and interpret our econometric results in this chapter. To start with, we summarize the descriptive statistics for the variables in table 3. We explain the results for the Augmented Dickey-Fuller unit root tests and the Johansen cointegration tests afterwards. We estimate the univariate and the panel vector autoregression models with various specifications, and make the summary tables 6, 7 and 8. Moreover, we perform several tests to ensure the robustness of the findings.

5.1. Descriptive Statistics for the Variables

After the original data are transformed in section 4.3, we summarize in table 3 the arithmetic means, the standard deviations and the numbers of observations for the variables of our interest. The data of the variables constitute an unbalanced panel. Thus, there are different numbers of observations for different variables from different cross sections. The numbers range from 59 to 252.

[Please insert Table 3 about here.]

For the foreign exchange (FX) rate and the nominal Gross Domestic Product (NGDP), cross sections with higher arithmetic means tend to have larger standard deviations. Arithmetic means of the savings rate (SR) and the investment rate (IR) are very approximate to each other across all the countries except for Greece (SR=12.510%, IR=20.032%) and Norway (SR=30.541%, IR=23.668%). 16 out of the 25 countries have positive arithmetic means for the nominal trade balance ratio (TBR), whereas 9 countries have negative means for the TBR. For the consumer price index

(CPI) and the industrial production index (IPI), we set one common base year for all the countries. Thus, countries with higher standard deviations in the CPI or the IPI have experienced more unstable fluctuations in the consumption prices or the total amounts of industrial production.

5.2. Augmented Dickey-Fuller Unit Root Test Results

The Augmented Dickey-Fuller (ADF) unit root test results provide unambiguous indications upon the property of stationarity of the tested variables. The null hypothesis of the ADF test is that unit root exists in the tested time series. We adopt the Akaike Information Criterion (AIC) and set the maximum number of lags of the variables to be 4. We summarize the results for the ten tested variables in table 4 and we could classified the results into the following categories.

[Please insert Table 4 about here.]

First, according to table 4, we cannot reject the null hypothesis of unit root for any of the foreign exchange (FX) rates. Since we derive the savings rate (SR) and the investment rate (IR) through the division of two variables, we could not directly examine their trend stationarity. Table 4 demonstrates that the unit root hypothesis cannot be rejected for either of the variables. Hence, both the SRs and the IRs are exclusively non-stationary.

Second, we cannot reject the null hypothesis for the savings-investment rate differential (SID) series for any of the countries except for Canada, Korea and New Zealand. In other words, the vast majority of the SIDs are non-stationary. In addition, we cannot reject the unit root hypothesis for the nominal trade balance ratios (TBRs) for any of the countries except for Australia, Korea, New Zealand, Poland and Turkey. Thus, the majority of the TBRs are non-stationary.

Third, as we expect, we reject the unit root hypothesis for both series of the difference in logarithm of the foreign exchange rate (FXC) and the difference in logarithm of the industrial production index (IPC) across all the countries. We hence conclude that the FXC and the IPC are exclusively stationary.

At last, we reject the null hypothesis of unit root for the difference in logarithm of the consumer price index (CPIC) for all the countries except for Australia, Germany and Turkey. For the difference in logarithm of the real Gross Domestic Product (RGDPC), we reject the null for all the cross sections except for Greece. Consequently, the majority of the CPIC and the RGDPC are stationary.

To summarize the findings of the ADF tests, on the one hand, we widely detect the unit root upon the level variables. More specifically, the FX rate, the SR and the IR are strictly non-stationary, whereas the vast majority of the SIDs and the TBRs are non-stationary. On the other hand, results for the growth variables demonstrate the opposite pictures. Both the IPC and the FXC are strictly stationary, whereas the majority of the CPIC and the RGDPC series are stationary processes.

5.3. Johansen Cointegration Test Results

We need to select among the non-stationary variables of the foreign exchange rate, the savings rate, the investment rate, the savings-investment rate differential and the nominal trade balance ratio to test for cointegration. This explains why we choose those specific combinations for the Johansen cointegration tests in section 3.1.4. The test allows for investigating multivariate cointegrating relations and exploring the linear combinations of those non-stationary variables to produce stationary processes. We summarize the test results in table 5.

[Please insert Table 5 about here.]

As we observe from table 5, the investment rate (IR) and the savings rate (SR) are cointegrated with the cointegrating vector of (1,-1). Consistent with what we expect, this finding strengthens the Feldstein-Horioka puzzle and urges us to introduce the savings-investment rate differential (SID) in section 4.3. Nevertheless, none of the rest of the tested combinations shows obvious indications of cointegrating relations. Consequently, estimating the error correction models that contain the foreign exchange rate is unnecessary.

5.4. Univariate Vector Autoregression Estimation Results

We assess each country individually with a vector autoregression (VAR) model in the first place. Table 6 is the summary table of our findings. Depending on the Akaike Information Criterion (AIC), the numbers of lags for the two endogenous variables, the FX rate and the SID vary across different countries. We notate the lagged time series of the FX rate and the SID in the formats of the FX (-1), FX (-2), SID (-1), SID (-2) and so forth. We generalize the main findings as follows.

[Please insert Table 6 about here.]

On the one hand, the effects of the SIDs upon the FX rates are highly unsatisfactory. Throughout our research, we concentrate on the usefulness of the historical SIDs on enhancing the predictability of the FX rates. Panel A demonstrates that the effects of the past SIDs on the FX rates are practically negligible for all the countries and this result is the exact opposite of our aspiration. Through variance decompositions, we found that less than 2% of the variances of the present FX rate stems from the lagged SID series and this finding is consistent for all the countries.

The other measure to accept the result is through assessing the statistical significance of the coefficient estimates before the variable FX (-1), the first lagged time series of the FX rates. Their coefficient estimates are statistically significant and equal to the unity across all the countries. Consequently, the overwhelming majority of variances of the FX rates are rooted in the FX (-1). Furthermore, multi-period variance decompositions reveal that the percentages of variances of the current FX rate explained by the FX (-1) vary from 98.58% to 99.99%.

On the other hand, to a certain extent, the FX rate could help predict the movement of the SID for most cross sections. More specifically, this case applies to 22 out of the 25 countries in the OECD since the coefficient estimates of the lagged FX rates for the current SIDs are statistically significant for these 22 countries. We also found that the proportions of variances of the present SIDs resulting from the past FX rates range from 5.78% to 65.20% across our sample. The effects of the historical FX rates on the current SIDs are, however, insignificant in three exceptional countries. They are respectively: Belgium, Iceland and Switzerland.

To conclude the findings of this section, we found that the coefficients of the lagged SID series in the first regression equation where the current FX rate is the dependent variable are statistically insignificant and therefore the SIDs are not helpful in forecasting the FX rate. On the contrary, the coefficient estimates of the historical FX rates upon the SID are significant for the vast majority of cross sections and we thus conclude that the past FX rates can improve the predictability of the SID.

5.5. Panel Vector Autoregression Estimation Results

Variables from different cross sections constitute an unbalanced panel in our research. We apply the two stage least squares to estimate the multivariate vector autoregression (VAR) model. Table 7 and table 8 present the estimation results for the first stage Ordinary Least Squares (OLS) regression and the second stage White-corrected regression respectively. We choose the first and the second lagged time series for both the FX rate and the SID through minimizing the Schwarz Information Criterion (SIC). We estimate the model with ten different specifications and interpret the findings in this section.

[Please insert Tables 7 and 8 about here.]

For the first equation I where the FX rate is the dependent variable, the coefficient estimates of the FX (-1) are universally significant at the 1% level of significance in both tables 7 and 8. Hence, within our expectations, the FX (-1) contributes to the overwhelming majority of the current FX rate. Nonetheless, the coefficient estimates of the lagged series of the SID, SID (-1) and SID (-2), are extremely insignificant for most specifications and correspond to those findings recorded in section 5.4. The present FX rate is thus mostly explained by its past series rather than the historical SIDs. Therefore, the SID cannot improve the predictability of the FX rate. Furthermore, we fail to detect any statistical significance of the lagged four exogenous variables, the nominal trade balance ratio (TBR), the difference in logarithm of the real Gross Domestic Product (RGDPC), the difference in logarithm of the consumer price index (CPIC) and the difference in logarithm of the industrial production index (IPC), in explaining the present FX rate. Consequently, we conclude that none of the exogenous variables would contribute to the forecasting of the FX rate.

When the SID is the dependent variable in the equation II, we observe, however, various statistical significance of the coefficient estimates before the explanatory variables. There are three substantial findings. First, the coefficient estimates of the historical SID series are statistically significant for the majority of specifications. Second, the coefficient estimates of the lagged FX rates, FX (-1) and FX (-2), are universally significant for all the specifications in both tables 7 and 8. The overwhelming majority of the coefficients are significant at the 1% level of significance with a couple of the estimates significant at the 5% level. These findings are also consistent with those reported in table 6 in section 5.4. Hence, the historical FX rates can help explain the present SID to a great extent. Third, the coefficient estimates of the TBR (-1) are extraordinarily significant for all the specifications. The TBR is strongly and positively correlated with the present SID, and thus contributes to explaining a considerable proportion of the SID. For the IPC (-1), all the coefficients are significant at a certain level and therefore the IPC (-1) could help predict the SID to some degree. Nevertheless, there is no evident significance in the lagged RGDPC or the lagged CPIC.

We also verify our findings by investigating the impulse response functions of the endogenous variables. Assigning one standard deviation to the two innovation terms in the two regression equations separately at the initial time 0, and assuming that the starting values of the FX rate and the SID are zeroes, we plot the impulse response functions of the FX rate and the SID until the period number 10. We present the functions in the figure 1.

[Please insert Figure 1 about here.]

Figure 1 shows the impulse response functions of the FX rate and the SID in the panel VAR model where we give the shock of one standard deviation at the time 0 to the error terms ε^{fx} and ε^{sid}. From panel A, we observe that with the number of the investigated period increases, the FX rate tends to decrease at a steady speed from the unity. Panel C shows that the SID experiences obvious fluctuations after the shock in the impulse of the FX rate. Therefore, the FX rate can help forecast the movement of the SID. Panel D demonstrates obvious unstable movement of the SID after the shock. Nonetheless, when the observed period increases, the response of the FX rate stabilizes and variations in the FX rate are measured with the magnitude of 10^{-3} in panel B. Hence, shocks in the impulse of the SID cannot trigger evident response in the FX rate.

To summarize the panel VAR results, when the FX rate is the explained variable, the coefficients of the FX (-1) are extremely significant whereas the coefficients of the past SIDs are insignificant. Therefore, the FX (-1) explains the vast majority of the current FX rate. When the SID is the predicted variable, the coefficient estimates of the historical FX rate series are statistically significant throughout the sample. By assigning external shocks of one standard deviation to each error term separately, and graphing the impulse response functions of the FX rate and the SID, we report similar findings. At last, we can conclude that the results of the univariate and the panel VAR estimations are consistent. Both models demonstrate that the historical SID series are not useful in forecasting the FX rate whereas the historical FX rates can improve the predictability of the SID to some degree.

To be specific, when the current SID is the explained variable, because the coefficient estimates of the FX (-1) are positive for all the specifications, we conclude that there is a positive correlation between the FX (-1) and the SID. In other words, an increase in the historical FX rate would lead to an increase in the SID. The economic explanations behind the relation are understandable. Since we collect the FX rates as the prices of non-US currencies required to purchase one United States Dollar (USD), when the numerical value of the FX rate increases, we require more units of the non-US currencies purchase one USD and thus the non-US currencies depreciate with respect to the USD. After the domestic currency depreciates, we would expect an obvious increase in the total exports since domestic products become more affordable to foreigners. In the meantime, the depreciated domestic currency would make the foreign products more expensive to domestic consumers and therefore inhibit the total imports from foreign countries. Therefore, the numerical value of the next exports (NX), which is the nominal trade balance (TB) in our thesis, increases.

According to the Keynesian four-sector (household, business, government, and foreign) equilibrium model in macroeconomics, for an open economy, the Gross Domestic Product (GDP) is assumed equal to the Gross National Income (GNI) and thus, the differential between domestic savings and domestic investment is the sum of the NX and the government deficit (GD)[5]. Therefore, with the increase in the NX, assuming that the government sector remains unchanged, we would expect an increase in the domestic savings-investment differential in the home country.

5 Assume that G is the government expenditure, C is the consumption, and T is the tax revenue of the government. I is the domestic investment and S is the domestic savings. The Keynesian four-sector model connects them through GDP= GNI, where GDP=C+G+I+NX and GNI=C+S+T. Then it can be easily derived that S-I=NX+(G-T), where (G-T) is the government deficit.

Controlling for the total amount of the GDP, the SID would increase accordingly. Vice versa. This also explains why the correlation between the trade balance ratio (TBR) and the SID is strongly positive in our panel VAR results.

5.6. Robustness Test for Fixed Effects

We specifically choose the five test options that correspond with the five model specifications where we consider the cross section fixed effects in section 5.5 and summarize the findings for testing the existence of country-specific fixed effects in table 9. Since we include 24 cross section dummies, the number of restrictions J for the test is 24.

[Please insert Table 9 about here.]

For the five different specifications, we report that the critical values are universally less than the corresponding test statistics. For example, in the specification number (1) where we include only the nominal trade balance ratio and the difference in logarithm of the real Gross Domestic Product as the exogenous variables, the Wald test statistic is 16.26, which is significantly larger than the critical value 1.80. Therefore, this suggests strong evidences against the null hypothesis of equal coefficient estimates of the dummies and we conclude that cross section fixed effects do exist as we expect. Consequently, the results we obtain in tables 7 and 8 are robust.

CHAPTER VI

CONCLUSION

Predicting the foreign exchange rate is of great concern to foreign exchange investors, businesses and government policy-makers. Much literature has attempted to explore the causes of the high exchange rate volatility but documented unsatisfactory findings. We concentrate our research on this issue and start by investigating two major unsolved puzzles in financial economics. First, the Feldstein-Horioka puzzle reveals the highly positive savings-investment correlation within the industrialized economies. Second, the Meese and Rogoff (1983a) compared several foreign exchange rate forecasting models and the finding was afterwards termed as the Meese-Rogoff forecasting puzzle which states that the traditional asset and monetary models cannot outperform the random walk in forecasting the foreign exchange rates over the short horizons.

Nevertheless, few studies have connected the forecasting of the foreign exchange rates with the investigation of the savings-investment relations. We combine the Feldstein-Horioka puzzle and the Meese-Rogoff forecasting puzzle in our research. Our thesis examines this research question: **since macroeconomic variables including the national savings and the domestic investment could affect the fluctuation of the foreign exchange rates, is it possible to improve the predictability of the foreign exchange rates through advanced panel econometric analyses?** We thus study the dynamic interrelations among these variables and concentrate on the reactions of the foreign exchange rates.

The first contribution of our research is that the present thesis differs from the previous studies by linking the Feldstein-Horioka puzzle with the Meese-Rogoff forecasting puzzle, and trying to solve the latter puzzle from the former perspective. Another major contribution is that we collect quarterly data of the foreign exchange rates and the macroeconomic variables from the first quarter in 1950 to the second quarter in 2013 for 25 cross section countries form the Organization for Economic Cooperation and Development. Panel vector autoregression (VAR) approach is generally applied for macroeconomic modeling and forecasting. Our study also contributes to extant literature since we perform the analyses through both the univariate and the multivariate VAR models. We have the following main findings.

Firstly, the Augmented Dickey-Fuller unit root tests performed upon the variables confirmed our expectation that the foreign exchange (FX) rates, the savings rates and the investment rates are exclusively unit root series. The overwhelming majority of the growth variables derived from the level variables are, nonetheless, stationary processes.

Secondly, the Johansen cointegration tests verified that the savings rate and the investment rate for our sample countries are cointegrated with the vector (1,-1). This finding is consistent with the results of the Feldstein and Horioka (1980) and numerous previous studies including the Feldstein (1983). Therefore we introduce the difference between the savings rate and the investment rate, the savings-investment rate differential (SID) in the subsequent model analyses.

Thirdly, we reported that the coefficient estimates of the historical SIDs for explaining the FX rate are exceedingly insignificant through the individual-specific VAR approach. This finding is universal across all the countries. By contrast, the coefficient estimates of the past FX rates upon the present SID are statistically significant for the vast majority of cross sections with the exceptions of Belgium, Iceland and Switzerland.

At last, the panel VAR estimations generated statistically insignificant coefficient estimates of the lagged SID series for the current FX rate. However, the coefficients of the lagged FX rates for the SID are significant regardless of the estimation specifications. In addition, we found that none of the exogenous variables is helpful in forecasting the FX rate, whereas the nominal trade balance ratio (TBR) and the difference in logarithm of the industrial production index (IPC) could improve the predictability of the SID to a considerable extent.

We observe that the estimation results of the univariate VAR and the panel VAR are consistent. According to these findings, we conclude that the historical SIDs are not useful in predicting the future movement of the FX rates. Instead, the results further strengthen the significantly high volatility of the FX rates. On the contrary, we conclude that the FX rates could help forecast the SIDs to some extent. More specifically, depreciated domestic currency would cause an increase in the SID in the home country over the short horizons.

Our results leave substantial implications upon the foreign exchange markets and the domestic economy. First, investors and corporate entities in the foreign exchange markets should not apply domestic savings or domestic investments to forecast the FX rate. Second, the government officials could predict the movement of future macroeconomic accounts including the savings and investments through investigating the historical FX rates, and therefore adjust the corresponding macroeconomic policies in the domestic markets. Finally, since the univariate VAR estimation results indicate that significant differences exist in the strength of correlations between the FX rate and the macroeconomic variables for different foreign exchange markets, the future studies could explore individual-specific factors that capture the disparities.

There are several limitations regarding our research. First, there is the lack of prior research that combines the studies of both the prediction of the foreign exchange rates and the savings-investment relations. Second, since the number of time series observations is significantly larger than the number of cross section countries in the panel, it is more difficult for us to consider the time series instead of the cross section fixed effects. We thus overlook the time series fixed effects. Finally, the original panel data we gathered are extremely unbalanced. We collect most of the macroeconomic accounts and indices from the DataStream, where data of the overwhelming majority of macroeconomic variables prior to 1980 are unavailable on the DataStream. However, for the foreign exchange rate and some macroeconomic indices including the industrial production index, their data collected from the Bloomberg Terminal could mostly trace back to 1950.

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Table 1: Cross Section Identifier for OECD Sample Countries

This table reports the cross section identifiers for the 25 sample countries from the Organization for Economic Cooperation and Development (OECD). These identifiers apply to all the collected data items, including the nominal Gross Domestic Product (NGDP), the nominal Gross Domestic Product Deflator, the Gross National Savings (GNS), the Gross Capital Formation (GCF), the Consumer Price Index (CPI), the Industrial Production Index (IPI), the total Export of goods and services as a Percentage of the nominal Gross Domestic Product (ExportR), the total Import of goods and services as a Percentage of the nominal Gross Domestic Product (ImportR) and the Foreign Exchange (FX) Rate. The first column lists the sample OECD countries and the second column lists the 1-to-25 cross section indices that correspond to the countries on the left.

OECD Country	Cross Section Identifier
Austria	1
Australia	2
Belgium	3
Canada	4
Czech Republic	5
Denmark	6
Finland	7
France	8
Germany	9
Greece	10
Hungary	11
Iceland	12
Italy	13
Japan	14
Korea, Republic of	15
Mexico	16
Netherlands	17
Norway	18
New Zealand	19
Poland	20
Sweden	21
Switzerland	22
Turkey	23
United Kingdom	24
United States of America	25

Table 2: Data Sources for Variables

This table presents the data sources for the nine variables we originally collected. These nine variables are the Foreign Exchange (FX) Rate, the Gross National Savings (GNS), the Gross Capital Formation (GCF), the nominal Gross Domestic Product (NGDP), the nominal Gross Domestic Product Deflator, the total Export of goods and services as a percentage of the nominal Gross Domestic Product (ExportR), the total Import of goods and services as a percentage of the nominal Gross Domestic Product (ImportR), the Consumer Price Index (CPI) and the Industrial Production Index (IPI). The first column lists the names of variables. The second column lists the sources or databases where the data are downloaded. The last column presents the terminals where these sources or databases in the second column are gathered.

Variable	Source	Terminal
Foreign Exchange Rate	*Oxford Economics*	Bloomberg Terminal
Gross National Savings	*Oxford Economics*	DataStream
Gross Capital Formation	*Quarterly National Accounts*	OECD website
Nominal Gross Domestic Product	*Oxford Economics*	DataStream
Nominal Gross Domestic Product Deflator	*Oxford Economics*	DataStream
Total Export, as a percentage of the Nominal Gross Domestic Product	*Oxford Economics*	DataStream
Total Import, as a percentage of the Nominal Gross Domestic Product	*Oxford Economics*	DataStream
Consumer Price Index	*Oxford Economics*	DataStream
Industrial Production Index	*World Economic Outlook*	Bloomberg Terminal

Table 3: Summary Statistics for Variables

This table reports the Arithmetic Mean (Mean), the Standard Deviation (SD) and the Number of Observations (NOB) for the variables of our interest for the 25 OECD countries. These variables are the Foreign Exchange Rate (FX Rate, ratio of local currency to United States Dollar), the nominal Gross Domestic Product (NGDP, in billions of local currency), the Savings Rate (SR, the Gross National Savings as a percentage of the nominal Gross Domestic Product), the Investment Rate (IR, the Gross Capital Formation as a percentage of the nominal Gross Domestic Product), the nominal Trade Balance Ratio (TBR, nominal Trade Balance as a percentage of the nominal Gross Domestic Product), the Consumer Price Index (CPI) and the Industrial Production Index (IPI). The maximum sample period is from the first quarter of 1950 to the second quarter of 2013. We round the arithmetic means and standard deviations of all the macroeconomic indices, and the foreign exchange rates to three decimal points.

Cross Section	Statistic	FX Rate	NGDP	SR	IR	TBR	CPI	IPI
Austria	Mean	15.080	45.728	23.946	23.793	1.474	77.080	55.801
	SD	3.788	18.507	1.819	1.288	2.482	16.800	30.911
	NOB	124	134	134	101	134	134	225
Australia	Mean	1.210	165.300	22.871	26.500	-1.159	55.711	79.386
	SD	0.308	101.259	2.158	2.089	1.283	27.525	18.709
	NOB	170	134	134	133	134	168	155
Belgium	Mean	38.874	56.124	22.779	20.486	0.656	86.737	65.031
	SD	7.810	22.223	3.296	2.050	4.152	19.441	25.914
	NOB	124	134	134	133	134	134	225
Canada	Mean	1.217	244.838	20.496	21.504	1.804	88.155	82.519
	SD	0.171	114.574	2.221	1.745	2.194	21.528	16.607
	NOB	170	134	134	134	134	134	134
Czech Republic	Mean	26.301	676.383	24.500	27.846	0.550	93.375	90.880
	SD	6.623	234.433	3.404	3.595	3.431	19.683	20.010
	NOB	82	82	82	73	82	82	81
Denmark	Mean	6.626	280.154	20.588	18.972	3.619	91.999	82.490
	SD	1.307	111.548	3.121	2.271	2.329	22.011	14.564
	NOB	170	134	134	133	134	134	134
Finland	Mean	4.693	28.095	23.283	22.232	3.275	77.613	54.316
	SD	0.889	12.421	4.126	4.898	3.833	18.714	31.132
	NOB	124	134	134	133	134	134	225

Table 3 (continued)

Cross Section	Statistic	FX Rate	NGDP	SR	IR	TBR	CPI	IPI
France	Mean	5.776	320.382	18.917	19.621	-0.206	94.955	74.499
	SD	1.239	118.759	1.769	1.628	1.579	20.861	22.053
	NOB	124	134	134	134	134	134	225
Germany	Mean	2.124	446.503	21.336	19.957	1.780	64.236	73.901
	SD	0.521	139.238	2.261	2.374	2.954	28.951	22.465
	NOB	124	134	134	90	134	234	221
Greece	Mean	2.566	27.330	12.510	20.032	-10.327	58.294	70.395
	SD	89.909	19.465	3.305	2.660	2.614	34.692	27.482
	NOB	83	134	134	125	134	134	225
Hungary	Mean	117.650	4026.794	22.292	23.016	-0.146	81.338	69.420
	SD	82.385	2277.024	3.964	5.018	4.288	39.565	26.724
	NOB	182	90	90	73	90	90	137
Iceland	Mean	39.747	270.830	19.338	21.423	-2.086	49.885	119.940
	SD	40.354	101.129	3.455	6.298	8.387	50.575	52.147
	NOB	226	65	65	65	65	202	60
Italy	Mean	1294.978	245.405	20.641	20.400	0.637	69.871	74.321
	SD	460.713	113.493	1.986	1.394	1.849	24.166	24.625
	NOB	124	134	134	93	134	134	225
Japan	Mean	166.111	110931.300	27.564	26.235	1.326	96.323	67.501
	SD	74.640	21420.630	4.547	4.282	1.299	7.320	31.106
	NOB	170	134	134	133	134	134	225
Korea	Mean	964.088	129811.400	32.283	31.738	1.395	63.805	45.511
	SD	213.743	99699.340	3.511	3.812	4.024	25.106	31.199
	NOB	129	134	134	133	134	134	134
Mexico	Mean	5.137	1258.371	21.040	24.194	0.315	62.214	59.155
	SD	4.997	1271.318	3.109	2.397	4.315	53.840	32.078
	NOB	170	134	134	81	134	134	225
Netherlands	Mean	2.324	90.862	25.479	20.756	5.280	82.622	69.114
	SD	0.513	38.327	2.495	2.543	2.386	17.045	26.232
	NOB	124	134	134	106	134	134	225
Norway	Mean	6.546	325.057	30.541	23.668	8.937	53.503	59.738
	SD	1.041	198.265	5.678	3.572	5.650	37.105	31.818
	NOB	170	134	134	134	134	234	225

Table 3 (continued)

Cross Section	Statistic	FX Rate	NGDP	SR	IR	TBR	CPI	IPI
New Zealand	Mean	1.472	31.812	21.141	21.135	0.781	46.798	82.464
	SD	0.418	11.794	2.221	2.269	1.625	40.802	17.124
	NOB	170	104	104	104	104	252	104
Poland	Mean	1.229	188.636	21.208	21.360	-6.661	104.498	78.708
	SD	1.566	124.106	9.338	7.219	10.359	48.302	32.053
	NOB	226	98	98	73	98	98	125
Sweden	Mean	6.621	492.54	22.600	18.908	4.479	91.303	83.319
	SD	1.590	230.980	3.312	2.597	2.966	24.871	18.641
	NOB	170	134	134	134	134	134	134
Switzerland	Mean	1.740	98.314	28.850	24.296	4.643	83.606	72.924
	SD	0.719	30.247	1.757	3.179	3.932	14.074	25.278
	NOB	170	134	134	133	134	134	218
Turkey	Mean	0.629	80.129	15.066	18.518	-1.303	54.401	73.064
	SD	0.713	113.719	3.909	4.214	3.263	71.489	30.436
	NOB	130	134	134	101	134	134	133
United Kingdom	Mean	0.581	215.157	15.645	17.266	-0.881	83.859	80.225
	SD	0.092	107.6520	2.254	2.013	1.769	22.888	16.117
	NOB	170	134	134	134	134	134	225
United States	Mean		2161.906	19.539	21.533	-2.566	157.322	61.783
	SD		1018.735	2.233	1.637	1.571	43.441	25.593
	NOB		134	134	134	134	134	225

Table 4: Augmented Dickey-Fuller Unit Root Test Summary

This table shows the results of the Augmented Dickey-Fuller (ADF) Fisher panel unit root tests for the nine selected variables. The null hypothesis is that there exists a unit root in each of the tested variable. We assume there is no intercept or linear trend in any of the tested variables. The maximum number of lags is four for all the variables. We apply the Akaike Information Criterion to select the number of lags. The level of significant for the test is 5%.

There are two methods to perform the ADF Fisher panel unit root test. They include the ADF Fisher Chi-square method and the ADF Choi Z-stat method. The first column lists names of the tested variables. We report the ADF Fisher Chi-square statistic and the probability value in the second and third columns respectively. We report the ADF Choi Z-stat statistic and the probability value in the fourth and fifth columns respectively. Panel A shows the section for the level variables whereas Panel B does that for the variables of growth rates.

Panel A. Level variables

Tested Variable	Fisher Chi-square Statistic	Probability Value	Choi Z-statistic	Probability Value
Foreign Exchange Rate	45.085	0.671	1.886	0.970
Savings Rate	41.218	0.807	0.191	0.576
Investment Rate	49.294	0.502	-1.224	0.111
Savings-Investment Rate Differential	110.829	0.000	-4.255	0.000
Nominal Trade Balance Ratio	131.614	0.000	-5.581	0.000

Panel B. Growth variables

Tested Variable	Fisher Chi-square Statistic	Probability Value	Choi Z-statistic	Probability Value
Difference in Logarithm of the Real Gross Domestic Product	732.295	0.000	-19.155	0.000
Difference in Logarithm of the Foreign Exchange Rate	1639.360	0.000	-35.117	0.000
Difference in Logarithm of the Consumer Price Index	238.822	0.000	-11.322	0.000
Difference in Logarithm of the Industrial Production Index	758.293	0.000	-24.371	0.000

Table 5: Johansen Cointegration Test Summary

This table shows the results of the Johansen Fisher panel cointegration tests for the six tested combinations of variables. The first column lists the specific tested combinations of variables. For each tested combinatioin, we assume that there is no linear trend in the data. Besides, we assume that there is no intercept or linear trend in the cointegrating equation or the vector autogression model. The level of significance for the test is 5%. We select the number of lag intervals to be four.
We compare the number of cointegrating vectors r with the number of variables k for each tested combination. There are two types of the Johansen Fisher cointegration test. They include the trace test and the maximum eigenvalue test. The null hypothesis is ($r \leqslant k$) for the trace test and ($r=k$) for the eigenvalue test. The second column presents the hypothesized number of cointegrating equation(s). We report the trace test statistic and the probability value in the third and fourth columns respectively. We report the maximum eigenvalue test statistic and the probability value in the fifth and sixth columns respectively.

Tested Combination	Hypothesized Number of Cointegrating Equation(s)	Trace Statistic	Probability Value	Max-Eigen Statistic	Probability Value
Investment Rate vs. Savings Rate	None	100.90	0.00	105.70	0.00
	At most 1	29.28	1.00	29.28	1.00
Foreign Exchange Rate vs. Nominal Trade Balance Ratio	None	90.16	0.00	95.58	0.00
	At most 1	25.09	1.00	25.09	1.00
Foreign Exchange Rate vs. Savings Rate	None	65.14	0.07	70.29	0.03
	At most 1	24.13	1.00	24.13	1.00
Foreign Exchange Rate vs. Investment Rate	None	50.58	0.45	53.92	0.33
	At most 1	27.46	0.99	27.46	0.99
Foreign Exchange Rate vs. Savings-Investment Rate Differential	None	95.39	0.00	99.98	0.00
	At most 1	28.08	0.99	28.08	0.99
Foreign Exchange Rate vs. Investment Rate vs. Savings Rate	None	117.70	0.00	121.00	0.00
	At most 1	38.78	0.88	40.02	0.84
	At most 2	27.69	0.99	27.69	0.99

Table 6: Univariate Vector Autoregression Summary

This table summarizes the estimation results of the univariate vector autoregression (VAR) for the 25 cross section countries. The foreign exchange (FX) rate and the savings-investment rate differential (SID) are the two endogenous variables. The four exogenous variables in the VAR are: the nominal trade balance ratio (TBR), the difference in logarithm of the real Gross Domestic Product (RGDPC), the difference in logarithm of the consumer price index (CPIC) and the difference in logarithm of the industrial production index (IPC). We apply the ordinary least squares to estimate the model. The number of observations and the number of lags for the endogenous variables vary for different cross sections. We select the numbers of lags through the Akaike Information Criterion. The number of observations is the maximum number of observations that all the dependent and the independent variables share.

After estimating the individual-specific VAR models, we investigate the mutual impacts of the FX rate and the SID on each other. We investigate both the impulse response functions and the variance decompositions to observe the impacts. We categorize the outcomes into four cases:

(a) The SID helps forecast the FX rate;

(b) The SID does not help forecast the FX rate;

(c) The FX rate helps forecast the SID;

(d) The FX rate does not help forecast the SID.

Panel A shows the section that discusses the impact of the SID on predicting the FX rate and Panel B does that for the reverse. Therefore, Panel A contains cases a and b, whereas Panel B contains cases c and d. We summarize the applicable cross section countries for each case in the third column. The fourth column sums up the total number of applicable cross sections for each case. Eventually, we calculate the frequencies of each case out of 25 and report them in the last column.

Panel A. Impact of the SID on predicting the FX rate

Case	Type	Applicable Cross Section Countries	Total Number of Applicable Cross Sections	Frequency
a	Impulse response	None	0	0/25=0%
	Variance decomposition	None	0	0/25=0%
b	Impulse response	All	25	25/25=100%
	Variance decomposition	All	25	25/25=100%

Panel B. Impact of the FX rate on predicting the SID

Case	Type	Applicable Cross Section Countries	Total Number of Applicable Cross Sections	Frequency
c	Impulse response	All, except for Belgium, Iceland, Switzerland	22	22/25=88%
	Variance decomposition	All, except for Belgium, Iceland, Switzerland	22	22/25=88%
d	Impulse response	Belgium, Iceland, Switzerland	3	3/25=12%
	Variance decomposition	Belgium, Iceland, Switzerland	3	3/25=12%

Table 7: Panel Vector Autoregression Summary with Ordinary Least Squares

This table presents the ordinary least squares regression results for the panel vector autoregression (VAR) model. The first column reports the explanatory variables in the model. The present foreign exchange (FX) rate is the dependent variable in the regression equation I whereas the present savings-investment rate differential (SID) is the explained variable in the equation II. The four exogenous variables in the VAR are: the nominal trade balance ratio (TBR), the difference in logarithm of the real Gross Domestic Product (RGDPC), the difference in logarithm of the consumer price index (CPIC) and the difference in logarithm of the industrial production index (IPC). We include a constant for both regression equations. Through the Schwarz Information Criterion, we choose the number of lags for the endogenous variables to be two. The numbers between the parentheses after the variables represent the corresponding lagged time series. For example, SID (-2) stands for the second lagged series of the SID.

We specify the following ten different options to estimate the model:

(1) TBR and RGDPC are included; CPIC and IPC are excluded; cross section fixed effects included,

(2) TBR and RGDPC are included; CPIC and IPC are excluded; cross section fixed effects excluded,

(3) CPIC and RGDPC are included; TBR and IPC are excluded; cross section fixed effects included,

(4) CPIC and RGDPC are included; TBR and IPC are excluded; cross section fixed effects excluded,

(5) CPIC, RGDPC, TBR and IPC are excluded; cross section fixed effects included,

(6) CPIC, RGDPC, TBR and IPC are excluded; cross section fixed effects excluded,

(7) CPIC and TBR are included; RGDPC and IPC are excluded; cross section fixed effects included,

(8) CPIC and TBR are included; RGDPC and IPC are excluded; cross section fixed effects excluded,

(9) CPIC, TBR and IPC are included; RGDPC are excluded; cross section fixed effects included,

(10) CPIC, TBR and IPC are included; RGDPC are excluded; cross section fixed effects excluded.

We report the standard errors between the parentheses. *, **, and *** denote statistical significance at 10%, 5%, and 1%, respectively. We also record the number of observations (No. of Obs.) and the adjusted R^2 for each regression.

Variable	(1)		(2)		(3)		(4)	
	I	II	I	II	I	II	I	II
FX (-1)	0.849***	0.009***	0.886***	0.008***	0.850***	0.007***	0.886***	0.007***
	(0.108)	(0.002)	(0.078)	(0.002)	(0.108)	(0.002)	(0.078)	(0.002)
FX (-2)	0.103	-0.006***	0.122	-0.007***	0.102	-0.004**	0.121	-0.007***
	(0.108)	(0.002)	(0.079)	(0.002)	(0.108)	(0.002)	(0.079)	(0.002)
SID (-1)	-0.049	0.083	-0.135	0.274***	-0.205	0.429***	-0.195***	0.517***
	(0.115)	(0.058)	(0.089)	(0.045)	(0.127)	(0.056)	(0.086)	(0.045)
SID (-2)	-0.033	0.012	-0.062	0.153***	-0.135	0.239***	-0.102	0.312***
	(0.148)	(0.049)	(0.108)	(0.040)	(0.127)	(0.056)	(0.090)	(0.045)
TBR (-1)	-0.328	0.729***	-0.114	0.463***				
	(90.223)	(0.056)	(0.120)	(0.032)				
RGDPC (-1)	-3.126	-3.109	-4.859	-0.110	-6.276	4.134	-6.058	4.366
	(7.198)	(3.095)	(6.316)	(2.795)	(7.069)	(3.773)	(6.065)	(3.263)
CPIC (-1)					-0.173	2.888	-0.193	-3.767
					(16.964)	(7.605)	(7.640)	(4.939)
IPC (-1)								
Fixed Effects	YES	YES	NO	NO	YES	YES	NO	NO
No. of Obs.	2262	2262	2262	2262	2262	2262	2262	2262
Adjusted R^2	0.888	0.495	0.885	0.422	0.888	0.366	0.885	0.330

Table 7 (continued)

Variable	(5)		(6)		(7)		(8)	
	I	II	I	II	I	II	I	II
FX (-1)	0.851***	0.007***	0.886***	0.007***	0.849***	0.009***	0.886***	0.008***
	(0.102)	(0.002)	(0.077)	(0.002)	(0.108)	(0.002)	(0.078)	(0.002)
FX (-2)	0.102	-0.004**	0.121	-0.007***	0.103	-0.006***	0.122	-0.007***
	(0.101)	(0.002)	(0.077)	(0.002)	(0.108)	(0.002)	(0.079)	(0.002)
SID (-1)	-0.173	0.424***	-0.175**	0.507***	-0.037	0.097	-0.117	0.274***
	(0.117)	(0.052)	(0.084)	(0.042)	(0.110)	(0.055)	(0.085)	(0.043)
SID (-2)	0.851***	0.007***	0.886***	0.007***	-0.033	0.009	-0.069	0.153***
	(0.102)	(0.002)	(0.077)	(0.002)	(0.149)	(0.049)	(0.110)	(0.039)
TBR (-1)					-0.340	0.718***	-0.125	0.463***
					(0.215)	(0.055)	(0.118)	(0.032)
RGDPC (-1)								
CPIC (-1)					3.461	-0.871	-0.228	-0.015
					(16.233)	(6.146)	(7.742)	(4.185)
IPC (-1)								
Fixed Effects	YES	YES	NO	NO	YES	YES	NO	NO
No. of Obs.	2262	2262	2262	2262	2262	2262	2262	2262
Adjusted R^2	0.888	0.362	0.885	0.327	0.888	0.494	0.885	0.422

Table 7 (continued)

Variable	(9)		(10)	
	I	II	I	II
FX (-1)	0.849***	0.009***	0.886***	0.008***
	(0.111)	(0.002)	(0.079)	(0.002)
FX (-2)	0.103	-0.006***	0.121	-0.007***
	(0.111)	(0.002)	(0.079)	(0.002)
SID (-1)	-0.015	0.105*	-0.102	0.283***
	(0.119)	(0.055)	(0.088)	(0.043)
SID (-2)	-0.038	0.007	-0.075	0.150***
	(0.148)	(0.050)	(0.108)	(0.040)
TBR (-1)	-0.356	0.713***	-0.133	0.459***
	(0.224)	(0.056)	(0.121)	(0.032)
RGDPC (-1)				
CPIC (-1)	4.746	-0.424	0.092	0.165
	(17.079)	(6.234)	(7.849)	(4.219)
IPC (-1)	6.229	2.166*	5.005	2.803***
	(15.105)	(1.118)	(9.338)	(0.906)
Fixed Effects	YES	YES	NO	NO
No. of Obs.	2262	2262	2262	2262
Adjusted R^2	0.888	0.495	0.885	0.424

Table 8: Panel Vector Autoregression Summary with White Corrections

This table reports the regression results with White corrections for the variance covariance matrices of the residuals of the first stage ordinary least squares regressions for the panel vector autoregression (VAR) model. The first column shows the explanatory variables in the model. The present foreign exchange (FX) rate is the dependent variable in the regression equation I whereas the present savings-investment rate differential (SID) is the explained variable in the equation II. The four exogenous variables in the VAR are: the nominal trade balance ratio (TBR), the difference in logarithm of the real Gross Domestic Product (RGDPC), the difference in logarithm of the consumer price index (CPIC) and the difference in logarithm of the industrial production index (IPC). We include a constant for both regression equations. Through the Schwarz Information Criterion, we choose the number of lags for the endogenous variables to be two. The numbers between the parentheses after the variables represent the corresponding lagged time series. For example, SID (-2) stands for the second lagged series of the SID.

We specify the following ten different options to estimate the model:

(1) TBR and RGDPC are included; CPIC and IPC are excluded; cross section fixed effects included,

(2) TBR and RGDPC are included; CPIC and IPC are excluded; cross section fixed effects excluded,

(3) CPIC and RGDPC are included; TBR and IPC are excluded; cross section fixed effects included,

(4) CPIC and RGDPC are included; TBR and IPC are excluded; cross section fixed effects excluded,

(5) CPIC, RGDPC, TBR and IPC are excluded; cross section fixed effects included,

(6) CPIC, RGDPC, TBR and IPC are excluded; cross section fixed effects excluded,

(7) CPIC and TBR are included; RGDPC and IPC are excluded; cross section fixed effects included,

(8) CPIC and TBR are included; RGDPC and IPC are excluded; cross section fixed effects excluded,

(9) CPIC, TBR and IPC are included; RGDPC are excluded; cross section fixed effects included,

(10) CPIC, TBR and IPC are included; RGDPC are excluded; cross section fixed effects excluded.

We report the standard errors between the parentheses. *, **, and *** denote statistical significance at 10%, 5%, and 1%, respectively. We also record the number of observations (No. of Obs.) and the adjusted R^2 for each regression.

Variable	(1)		(2)		(3)		(4)	
	I	II	I	II	I	II	I	II
FX (-1)	0.989***	0.010***	1.039***	0.006***	0.994***	0.009***	1.038***	0.005***
	(0.048)	(0.002)	(0.037)	(0.001)	(0.047)	(0.002)	(0.037)	(0.001)
FX (-2)	-0.030	-0.007***	-0.037	-0.006***	-0.035	-0.007***	-0.037	-0.005***
	(0.048)	(0.002)	(0.037)	(0.001)	(0.047)	(0.002)	(0.037)	(0.001)
SID (-1)	-0.000	0.422***	0.001	0.614***	-0.001	0.643***	0.001	0.705***
	(0.016)	(0.032)	(0.010)	(0.023)	(0.015)	(0.027)	(0.010)	(0.021)
SID (-2)	-0.005	0.070***	-0.004	0.210***	-0.008	0.166***	-0.005	0.248***
	(0.015)	(0.027)	(0.009)	(0.021)	(0.015)	(0.027)	(0.010)	(0.021)
TBR (-1)	-0.006	0.385***	-0.001	0.141***				
	(0.020)	(0.030)	(0.010)	(0.015)				
RGDPC (-1)	0.160	2.078	0.143	1.347	0.217	3.646	0.195	1.357
	(1.173)	(2.339)	(0.733)	(1.870)	(1.135)	(2.182)	(0.771)	(1.748)
CPIC(-1)					0.528	-2.826	0.529	-2.023
					(2.246)	(3.702)	(1.136)	(2.574)
IPC (-1)								
Fixed Effects	YES	YES	NO	NO	YES	YES	NO	NO
No. of Obs.	2262	2262	2262	2262	2262	2262	2262	2262
Adjusted R^2	0.885	0.444	0.882	0.345	0.885	0.332	0.882	0.290

Table 8 (continued)

Variable	(5)		(6)		(7)		(8)	
	I	II	I	II	I	II	I	II
FX (-1)	1.006***	0.008***	1.044***	0.005***	0.989***	0.010***	1.039***	0.006***
	(0.042)	(0.002)	(0.034)	(0.001)	(0.049)	(0.002)	(0.036)	(0.001)
FX (-2)	-0.048	-0.006***	-0.043	-0.005***	-0.030	-0.007***	-0.037	-0.006***
	(0.042)	(0.002)	(0.034)	(0.001)	(0.048)	(0.002)	(0.037)	(0.001)
SID (-1)	-0.001	0.634***	0.001	0.701***	-0.001	0.420***	-0.000	0.612***
	(0.011)	(0.026)	(0.008)	(0.020)	(0.015)	(0.031)	(0.009)	(0.022)
SID (-2)	1.006	0.008***	1.044	0.005***	-0.005	0.071***	-0.003	0.211***
	(0.042)	(0.002)	(0.034)	(0.001)	(0.015)	(0.027)	(0.009)	(0.021)
TBR (-1)					-0.006	0.383***	-0.000	0.142***
					(0.020)	(0.030)	(0.010)	(0.015)
RGDPC (-1)								
CPIC (-1)					0.487	-5.348	0.492	-2.635
					(2.146)	(4.170)	(1.041)	(2.688)
IPC (-1)								
Fixed Effects	YES	YES	NO	NO	YES	YES	NO	NO
No. of Obs.	2262	2262	2262	2262	2262	2262	2262	2262
Adjusted R^2	0.885	0.331	0.882	0.290	0.885	0.444	0.882	0.345

Table 8 (continued)

Variable	(9)		(10)	
	I	II	I	II
FX (-1)	0.989***	0.010***	1.041***	0.006***
	(0.050)	(0.002)	(0.037)	(0.001)
FX (-2)	-0.030	-0.007***	-0.040	-0.006***
	(0.049)	(0.002)	(0.037)	(0.001)
SID (-1)	0.000	0.421***	-0.000	0.609***
	(0.016)	(0.031)	(0.010)	(0.022)
SID (-2)	-0.003	0.070***	-0.002	0.208***
	(0.016)	(0.027)	(0.010)	(0.021)
TBR (-1)	-0.009	0.379***	-0.002	0.144***
	(0.021)	(0.030)	(0.010)	(0.015)
RGDPC (-1)				
CPIC (-1)	0.651	-5.585	0.674	-2.754
	(2.279)	(4.213)	(1.133)	(2.719)
IPC (-1)	0.478	1.399**	0.380	1.529***
	(0.580)	(0.667)	(0.356)	(0.490)
Fixed Effects	YES	YES	NO	NO
No. of Obs.	2262	2262	2262	2262
Adjusted R^2	0.885	0.445	0.881	0.349

Table 9: Wald Test for Fixed Effects

This table reports the results of the Wald test for cross section fixed effects. The present foreign exchange (FX) rate is the dependent variable in the regression equation I whereas the present savings-investment rate differential (SID) is the explained variable in the equation II. The first column lists the names of the reported items. We also report the test results of whether the null hypothesis is rejected in the bottom row.

The null hypothesis is that the coefficient estimates for the 24 cross section dummies are equal and thus there is no cross section fixed effects in our panel. The distribution of the test statistics under the null hypothesis is the F-distribution with the degrees of freedom J and (n-k), where J is the number of restrictions, n is the total number of observations and k is the number of explanatory variables. We specify the level of significance to be 1%. We choose the following five specifications to perform the test:

(1) TBR and RGDPC are included; CPIC and IPC are excluded; cross section fixed effects included,

(2) CPIC and RGDPC are included; TBR and IPC are excluded; cross section fixed effects included,

(3) CPIC, RGDPC, TBR and IPC are excluded; cross section fixed effects included,

(4) CPIC and TBR are included; RGDPC and IPC are excluded; cross section fixed effects included,

(5) CPIC, TBR and IPC are included; RGDPC are excluded; cross section fixed effects included.

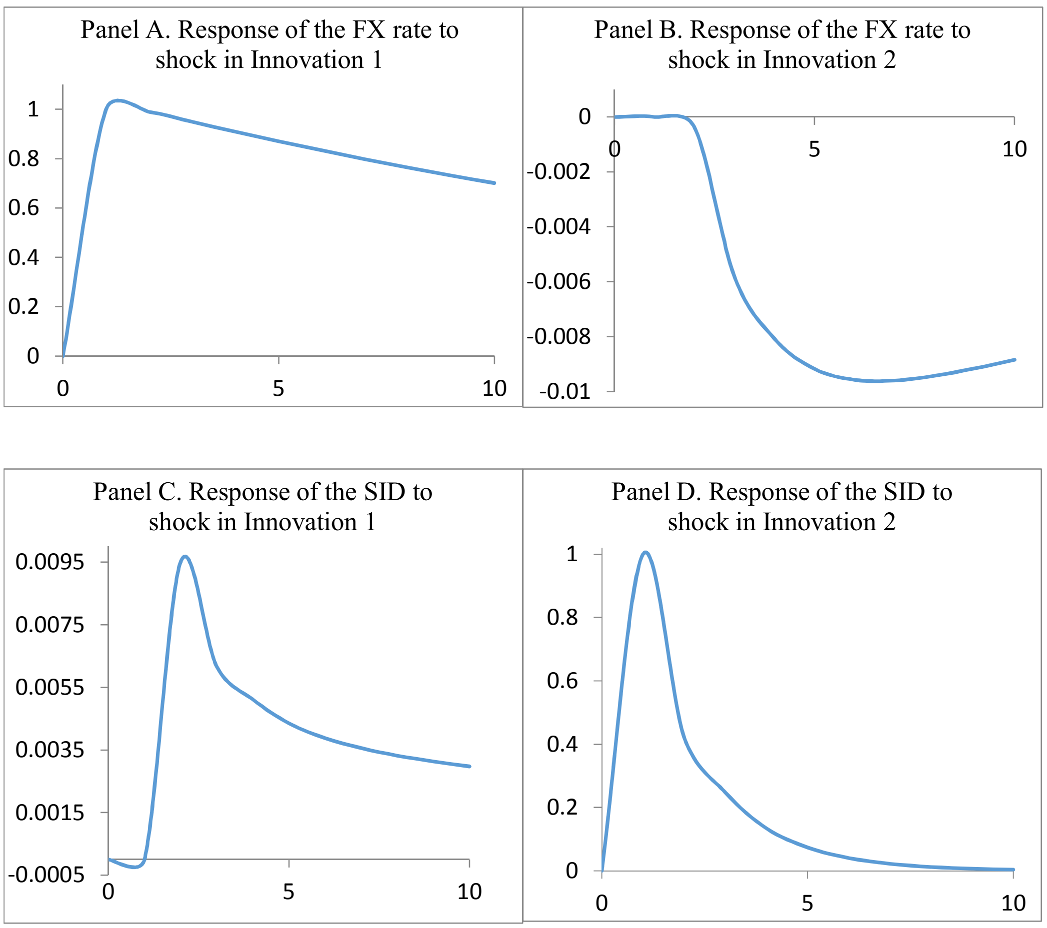
	(1)		(2)		(3)	
	I	II	I	II	I	II
J	24	24	24	24	24	24
N	2262	2262	2262	2262	2262	2262
K	32	32	32	32	29	29
n-k	2230	2230	2230	2230	2233	2233
Test Statistic	16.26	155.92	16.73	82.23	20.77	89.02
Critical Value	1.80	1.80	1.80	1.80	1.80	1.80
Test Result	Rejected	Rejected	Rejected	Rejected	Rejected	Rejected

Table 9 (continued)

	(4)		(5)	
	I	II	I	II
J	24	24	24	24
N	2262	2262	2262	2262
K	32	32	33	33
n-k	2230	2230	2229	2229
Test Statistic	16.16	155.81	15.47	152.55
Critical Value	1.80	1.80	1.80	1.80
Test Result	Rejected	Rejected	Rejected	Rejected

Figure 1: Impulse Response Functions of the FX rate and the SID

This figure shows the impulse response functions of the two endogenous variables, the foreign exchange (FX) rate and the savings-investment rate differential (SID). After we report the panel vector autoregression (VAR) results, we choose the estimation results of the specification number (1) where we include the nominal trade balance ratio (TBR) and the difference in logarithm of the real Gross Domestic Product (RGDPC), exclude the difference in logarithm of the consumer price index (CIPC) and the difference in logarithm of the industrial production index (IPC), and consider the cross section fixed effects. We give the innovation terms ε^{fx} (Innovation 1) and ε^{sid} (Innovation 2) one standard deviation shock respectively at time 0. We record the response data of the FX rate and the SID from time 1 to 10. We assume that the starting values of the FX rate and the SID are zeroes. Panels A and B show the impulse response functions of the FX rate, whereas panels C and D show the impulse response functions of the SID.



APPENDIX: LIST OF ABBREVIATIONS

PPP: Purchasing Power Parity.

UIRP: Uncovered Interest Rate Parity.

FX: Foreign Exchange.

SR: Savings Rate.

IR: Investment Rate.

SID: Savings-Investment Rate Differential.

GDP: Gross Domestic Product.

NGDP: Nominal Gross Domestic Product.

RGDP: Real Gross Domestic Product.

TBR: Nominal Trade Balance as a Ratio of the nominal Gross Domestic Product.

CPI: Consumer Price Index.

IPI: Industrial Production Index.

FXC: Difference in Logarithm of the Foreign Exchange Rate.

RGDPC: Difference in Logarithm of the Real Gross Domestic Product.

CPIC: Difference in Logarithm of the Consumer Price Index.

IPC: Difference in Logarithm of the Industrial Production Index.

OECD: Organization for Economic Cooperation and Development.

VAR: Vector Autoregression.