Dynamics of macroeconomic and financial variables in different time horizons

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When I first came to Sweden as an exchange student, I did not expect that I would stay in Sweden longer than a year. Then, there were two professors who had an influence on me to change my course of life. Professor Scott Hacker has been my main supervisor since I wrote my master’s thesis at JIBS. With his close and thorough guidance in the process of writing my dissertation, I learned a lot about how to put together economic intuition with econometrics. I deeply appreciate his time and efforts in improving the quality of my dissertation over the years. The other professor was Professor Börje Johansson who taught me advanced microeconomics and international trade theory when I was in the exchange program. I first learned of the possibility of applying for the doctoral program at JIBS from Professor Johansson. If it had not been for his remarks, I would have left Sweden for good right after I had finished the one-year long exchange program. I also benefited from valuable comments and suggestions from my second supervisor, Professor Åke Andersson. His deep and broad knowledge in economics has been inspiring to many doctoral students including myself. I am also grateful to my third supervisor, Professor Hubert Fromlet for his guidance and inspiration. He also has helped me with finding the right persons to contact based on his world-wide network of scholars and practitioners. I would like to express my gratitude to the two professors in statistics, Professor Ghazi Shukur, and Professor Thomas Holgersson, for their guidance in learning econometrics and helping me with finding ways to solve problems. I would like to express my special thanks to Professor Shukur who taught me wavelet analysis and helped me with finding a way out when I was stuck with problems. I thank Associate Professor Bo Sjö for the comments on my papers at the final seminar and Professor Abdulnasser Hatemi-J for his additional comments and suggestions. I also thank for their constructive comments the discussants at the Friday seminars of the Economics, Finance and Statistics department, including Kristofer Månsson and professors Andreas Stephan, Agostino Manduchi and Pär Sjölander.

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Jönköping, 1 March 2012

Hynjoo Kim Karlsson
Abstract

This dissertation consists of an introductory chapter and four papers dealing with financial issues of open economies, which can be in two broad categorizations: 1) exchange rate movements and 2) stock market interdependence. The first paper covers how the exchange rate changes affect the prices of internationally traded goods. With the variables (the price of exports in exporters’ currency and the exchange rate, both of which are in logarithmic form) being cointegrated, a model with both long- and short-run characteristics (the Error Correction Model, ECM) is formulated. By using prices of major exports from South Korea to different destinations over the world, how the markup adjustment of those exports varies with respect to changes in exchange rates is estimated empirically under the context of pricing-to-market (PTM).

The second paper relates to the standard macroeconomic models of exchange rate determination. This paper investigates the relationship between the exchange rate and the domestic-foreign interest rate differential. The associated regression model follows the form of earlier literature in testing the effect of the interest rate differential on the exchange rate although the use of wavelet-decomposed levels of the data series distinguishes this paper from the earlier empirical works.

A relevant issue associated with the relationship between export prices and exchange rates for different industries is found in the third paper. The responsiveness of firms’ profitability to changes in exchange rates (i.e. exchange rate exposure) is tested using a factor model. Following specifications of the earlier literature on this subject, returns of various industries (or sectors) of the US stock market are regressed on the changes in exchange rates as well as the excess return on the market portfolio. The Kalman filter is used to estimate time-varying coefficients (beta) of the variables at different frequencies (daily, weekly, monthly, quarterly and annually).

After the three papers noted above, the dissertation moves on to the final paper which explores the relationship between national stock markets (i.e. interdependence). The causal linkages of the U.S. stock market to each of six eastern Asian national stock markets (China, Hong Kong, Japan, Singapore, South Korea and Taiwan) as well as the causal linkages among those Asian equity markets are tested in a vector autoregression (VAR) model using wavelet-decomposed data.
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Part I

Introduction to the thesis
I Introduction and Overview

1.1. Motivation and Scope

This dissertation deals with various financial issues of open economies in two broad categorizations: 1) exchange rate movements; and 2) stock market interdependence. The former covers the relationships between exchange rate movements and other macroeconomic and industry-level variables, and the latter deals with interdependence of the equity markets across national borders.

The influence of exchange rates in national economies has been increasing due to their association with the internationalization of business, the growing volume of the world trade, and the rapid cross-border mobility of monies due to technological developments. In an open economy exchange rates are an interest not only confined to researchers in economics, as these rates can have a strong impact on many parts of such an economy. Industrial competitiveness at the level of firms or industries (sectors, at a narrower categorization), stock market prices, and the outlook for national economies and the world economy are all affected by exchange rates. Studies within the area of international finance for the past fifty years thus have been heavily dealing with exchange rate issues with theoretical, empirical and policy-implication contributions. Against this backdrop, this dissertation investigates exchange rate determination, especially the effect of interest rates on the exchange rates, and explores how the exchange rates affect export prices and stock returns.

By the 1980s there had been substantial theoretical developments on how monetary and fiscal variables affect exchange rates. The exchange rate theories of the time unfortunately failed empirically to explain the systematic patterns of movements in the nominal and real exchange rates. Statistical tests by Meese and Rogoff (1983) had shown that a random walk model performs no worse than macroeconomic models in predicting nominal and real exchange rates. This meant that variations in these variables appear to be purely random and leave no pattern over time, thereby making predictions insignificant. This seminal work on testing the performance of monetary models for forecasting exchange rate movements, however, had a number of econometric problems such as endogenous explanatory variables and nonstationarity of regression variables, thus correcting for these problems has spawned a wealth of empirical
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Along with the increasing availability of high-frequency data series, developments in statistical test methods in the 1990s enabled researchers to find evidence of statistically significant forecast ability of exchange rates at long horizons (Mark 1995; Mark and Sul, 2001; Rapach and Wohar, 2002; Faust, Rogers and Wright, 2001 among others). Moreover, results from research on economic/financial time series over different time horizons have been accumulated leading to the realization that the characteristics of movements in those variables are often not constant over time. To support analysis of economic/financial variables while preserving their features in time as well as dealing with their non-stationary characteristics, a filtering method which used to be dominant in engineering community – the Kalman filter – started to be employed in economics and finance. Around the same time period, studies on exchange rate models did not confine themselves only to a partial equilibrium framework but reached to the general equilibrium setting based on profound microfoundations.

Research on exchange rates has also been invigorated by the growing number of studies on the relationships between prices of internationally traded goods and exchange rate movement, which can be categorized into three related branches of literature. The first regards testing an economic principle that identical products tend to be sold at the same common-currency price in different locations across borders; i.e. whether the law of one price (LOP) holds. The second deals the question about the effect of changes in currency value on the trade balance and domestic inflation. Empirical tests in this branch of literature have focused on the degree to which export and import prices react to exchange rate movements, known as the degree of exchange rate pass-through (ERPT) relationship. By blending the foundations of the LOP and ERPT studies, the third branch of literature focuses more on exporters’ pricing discrimination in international markets under exchange rate fluctuations, a phenomenon referred to as pricing-to-market (PTM) (Goldberg and Knetter, 1997).

Exchange rates movements are also associated with industry returns while the reaction of returns performance to exchange rate changes should be different in different industries. One expectation is that industries with substantial US production and heavy involvement in exports should be negatively affected by appreciation of the US dollar due to loss of competitiveness. For industries with substantial multinational involvement the opposite may be expected in some cases due to the gain in competitiveness for subsidiaries outside the US, although the appreciation causes foreign revenues
in dollar terms to diminish for the same amount sold, which could then be reflected in lower returns in dollar terms. The value of intermediate goods from abroad also has an impact on how the exchange rate affects industry returns, with industries that rely more heavily on non-US intermediate goods being positively affected by a dollar appreciation as foreign inputs appear cheaper in US dollars. Such an exchange rate relationship with industry returns gets further complicated by a causal relationship opposite to that considered above. For example if an industry's stock prices show a strong upward trend while those in other industries are flat, investors from outside the US will be induced to invest in the industry with the growing returns, putting upward pressure on the dollar. By this means, a positive relationship between an industry's returns and the value of the dollar may be observed.

An increase in investments outside domestic markets, the introduction of the liberalization measures, and technological advancements have led international financial markets to being substantially integrated in recent years. National stock market returns thus are interdependent on the performance of the equity markets across the national borders, which is one of the issues of interest for open economies. A greater integration of the equity markets has led them to have a tendency to move more together, which is a concern for investors given that international diversification is more beneficial when markets do not move together closely.

In this dissertation, I provide a selective coverage of topics briefly mentioned above within international macroeconomics and finance. Throughout this dissertation my aim is to make empirical contributions by investigating the aforementioned relationships – between exchange rates and other macroeconomic/financial variables and between different national stock markets – at different time horizons. Economic theories often draw a distinction between short- and long-run phenomena, which is structured around price fixity (or stickiness); prices are assumed to be sticky as a short-run feature, while the assumption is relaxed in the long-run considerations. However, having dichotomous time horizons only, short and long, might be questionable to apply to real world phenomena.
1.2. Heterogeneity, market ecology and time-frequency analysis

Other than the economic theories with different assumptions on the speed of price movement, the rationale of the time-varying or scale-varying movement of the economic and financial variables can be found from the characteristics of markets as being heterogeneous and evolving ecosystems. Participants of financial markets are composed of a spectrum of traders with different trading time horizons/frequencies. Market makers are those who take up the excess of directional orders of buy and sell. This high-frequency strategy provides liquidity in the market and tries to exploit profit from the bid-ask spread. There are intraday traders who trade within a given trading day and day traders who may carry trading positions overnight, both of whom have time scales of weeks or days, or even shorter in some cases. Trend traders attempt to identify price patterns over time and trade in such a direction that they can profit from the price movements. It would therefore be reasonable to think that their trading decisions would be based on frequencies ranging from a few days to a small number of years.

Considering different time horizons/frequencies in investigating economic/financial series relates to heterogeneous strategies and beliefs among investors arising from asymmetric information and liquidity. These heterogeneous strategies and beliefs form a type of evolving ecosystem.1 The interrelationship between the financial market participants with those heterogeneous strategies and beliefs has been previously studied: an example of such market participants being noise traders2 whose trading increases liquidity in the market. Their trading makes the traders acting on information more profitable and eventually makes the price of a stock move back toward its value over time (Black, 1986).

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1 Farmer (2002) uses the term ‘ecology’ for two reasons. Firstly, in analogy with biology, agents in the financial markets are interrelated with each other and with the environment, which has an influence on price and trading strategy in a feedback system. Secondly, instead of delving into the drives for their strategy, utility maximization, for example, common trading strategies are taken as given.

2 Noise is defined differently in different models in Black (1986). The common element though is that people trade on noise as if it were information and such trading is essential to the existence of liquid markets. Dow and Gorton (2008) provides a brief review on noise traders.
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Even though behavioral, agent-based approaches where boundedly rational, heterogeneous agents populate the markets provide convincing explanations to the deviations from the equilibrium, investigating heterogeneous agent models in detail is not the purpose of this dissertation. However, heterogeneity and the resulting ecology provide justification to doing empirical studies over different frequencies or (time) scales.

1.3. Organization of the papers

This dissertation consists of four papers. Variables of particular interest and the direction of the relationship between those variables for each of the four papers are presented in Figure 1 below. The first paper covers how exchange rate changes affect the prices of internationally traded goods. Assuming the variables (the price of exports in exporters’ currency and the exchange rate, both of which are in logarithmic form) are cointegrated, a model with both long- and short-run characteristics (the Error Correction Model, ECM) is formulated. By using prices of major exports from South Korea to different destinations over the world, how markup adjustments of those exports vary with respect to changes in the exchange rate is estimated empirically under the context of pricing-to-market (PTM).
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Figure 1. Key variables and methodologies of the papers included.

Note that arrows denote the direction of the relationship between the variables investigated.

The second paper relates to the standard macroeconomic models of exchange rate determination. This paper investigates the relationship between the exchange rate and the domestic-foreign interest rate differential. The associated regression model follows the form of earlier literature in testing the effect of the interest rate differential on the exchange rate although the use of wavelet-decomposed levels of the data series distinguishes this paper from the earlier empirical works (a brief description of this wavelet decomposition is presented in a section 6).

A relevant issue associated with the relationship between export prices and exchange rates for different industries is found in the third paper. The responsiveness of firms’ profitability to changes in exchange rates (i.e. exchange rate exposure) is tested using a factor model. Following specifications of the earlier literature on this subject, returns of various industries (or sectors) of the U.S. stock market are regressed on the changes in exchange rates as well as the return on the market portfolio. The Kalman filter is used to estimate time-varying coefficients (beta) of the variables at different frequencies (daily, weekly, monthly, and quarterly).

After the three papers noted above, the dissertation moves on to the final paper which explores the relationship between national stock markets (i.e. interdependence). The causal linkages of the U.S. stock market to each of six eastern Asian national stock markets (China, Hong Kong, Japan, Singapore, South Korea and Taiwan) as well as the causal linkages among those Asian equity markets are tested in a vector autoregression (VAR) model using wavelet-decomposed data.

The rest of the current chapter proceeds as follows. Section 2 surveys theoretical and empirical relationships between exchange rates and goods prices, which is followed by theories on the exchanges rate determination in section 3. Section 4 presents a discussion of asset pricing models, exchange rate exposure, and time varying parameters, then the chapter moves on to the issue

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3 The term *interdependence* is used to refer to the situation where market correlation suggests strong linkages between the two economies at any continued high level. Another relevant term, *contagion*, is defined as a significant increase in cross-market linkages caused by a shock such as the financial crisis in the late 1990s (Forbes and Rigobon, 2002).
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of interdependence among national stock markets in section 5. Lastly, an outline of the four papers included in this dissertation is presented in section 6.
2. Exchange rate fluctuations and markup adjustments

This section surveys the literature on the relationship between exchange rate movements and internationally traded goods prices, which relates to the first dissertation paper on how exchange rate fluctuations affect the pricing of exports for various industries in South Korea, focusing on exporters’ price discrimination across different destination markets over the world. This strand of empirical study follows in the vein of the other two categories of literature, the law of one price (LOP) and exchange rate pass-through (ERPT), both of which are within the research area on the relationship between prices of internationally traded goods and exchange rates being such that: the prices of foreign goods are not fully responsive to the changes in exchange rates. Put another way, the effect of exchange rate movements are passed through into the export and import prices thereby muting the price response. Such a smoothed response of the price response may be attributed to the destination-specific market adjustment, referred to as ‘pricing to market’ (PTM). The issue of purchasing power parity (PPP), which is closely associated with LOP, is relevant for the second paper on the relationship between exchange rates and interest rate differentials.

2.1. The law of one price (LOP)

The law of the one price (LOP) which postulates that the same good should be priced the same regardless of where it sold once it is expressed in a common currency. The LOP in its absolute version may be written as:

\[ P_{i,t} = E_t P_{i,t}^* \]

\[ i = 1, 2, ..., N \]

where \( P_{i,t} \) and \( P_{i,t}^* \) denote respectively the domestic and foreign prices of a good \( i \) at time \( t \) in terms of their respective currencies and \( E_t \) is the spot exchange rate (domestic currency per foreign currency) at time \( t \). The frictionless goods arbitrage and the perfect substitutability between domestic and foreign goods provide the rationale behind the LOP condition. The existence of trade barriers (tariff and non-tariff barriers), transportation costs,
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and product differentiation across countries, however, create a wedge between the domestic and foreign prices and a failure of LOP.

In its relative version the LOP condition is:

\[
\frac{P_{i,t+1}E_{t+1}}{P_{i,t+1}} = \frac{P_{i,t}E_t}{P_{i,t}} = \omega_i \quad i = 1, 2, \ldots, N
\]

(1)

where \(\omega_i\), the real exchange rate for the good \(i\), is constant over time, so the foreign price as a percentage of the domestic price at a common currency is unchanged over time. At the aggregate level is the associated concept of relative purchasing power parity (PPP), by which is meant is that the rate of depreciation of a currency equals the difference in price inflation of that currency's country and the price inflation in the other country. There have been extensive empirical studies on PPP using various econometric test procedures: cointegration analysis (Kim, 1990; Cheung and Lai, 1993); long-span studies (Frankel, 1986; Glen; 1992; Hegwood and Papell, 1999); panel data analysis (Flood and Taylor, 1996; Frankel and Rose, 1996; Taylor and Sarno, 1998); and non-linear econometric techniques (Obstfeld and Taylor, 1998; Taylor, Peel and Sarno, 2001). I present below an equation for testing the LOP, without giving a detailed account of the econometric procedure, due to its relevance to the exchange rate pass-through and pricing-to-market. Details will be revisited in corresponding following sections.

Testing the LOP maybe done with the following regression model:

\[
p_t = \alpha + \beta p^*_t + \gamma e_t + \varepsilon_t
\]

(2)

where \(p\) is the logged home currency price in the Home country, \(e\) is the logged spot exchange rate defined as units of Home currency per unit of Foreign currency, \(p^*\) is the logged price in the Foreign country, \(\varepsilon\) denotes an error term, and \(t\) denotes time period. The subscript \(i\) to denote a particular good is suppressed on \(p\) and \(p^*\) for simplicity. The absolute LOP implies that \(\alpha = 0, \beta = 1\) and \(\gamma = 1\) if prices are measured in different currency units while it implies \(\alpha = 0, \beta = 1,\) and \(\gamma = 0\) if they are measured in the same currency units. Testing for the LOP is typically done in its relative form, with a non-zero arbitrary constant, to mitigate the following two problems in its absolute version. Firstly, complete equality of the prices crossing borders is unlikely due to the fact that goods arbitrage across border is not costless. Trade and non-trade barriers, transportation costs, the costs of using distribution
channels, and the costs of gathering information on the local market cause frictions in the arbitrage process. Secondly, the identical goods assumption is violated to some degree because products made in different locations over the world have different physical or non-physical (delivery date and invoice currency) characteristics.4

The source of the evidence against the LOP is found from the coefficient estimate, $\gamma$, in equation (2) (Isard, 1977; Richardson, 1978; Giovannini, 1988). In general, empirical studies on the LOP have tested and rejected the LOP for various products and countries (Rogoff, 1996). This evidence relates to the question of the transmission of nominal exchange rate changes to import or export prices (exchange rate pass-through) and price discrimination for different markets (pricing-to-market).

2.2. Exchange rate pass-through (ERPT)

Studies on exchange rate pass-through (ERPT) investigate the degree to which exchange rate changes are reflected into the traded goods, typically using the following general empirical form:

$$p_t = \alpha + \beta x_t + \gamma e_t + \delta' z_t + \epsilon_t$$

(3)

where $p$ is the logged local currency import price; $e$ is the logged spot exchange rate, defined as units of importer’s currency per unit of exporter’s currency; $x$ is a control variable measuring exporter’s cost (marginal cost of production or aggregate factor prices); and $z$ is a vector indicating other control variables such as an import demand shifter, for example, income or expenditure on all varieties of goods by the importing country. The connection between the LOP and ERPT is clear if the $z$ vector in the equation (3) contains the price prevailing in the exporting country for the import good whose price is measured by $p$. Otherwise, the connection becomes unclear (Goldberg and Knetter, 1997).

4 An arbitrary constant mitigates problems of the absolute LOP by allowing some frictions (costs) which are stable (being a constant proportion of price for conducting international trade) over time. Some frictions such as transportation costs, however, vary depending on weights for transportation, which may introduce noise into the relationship (Goldberg and Knetter, 1997).
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The degree to which exchange rate changes are reflected into the prices of traded goods can be considered in two respects: prices of imports into a domestic country and prices of exports from the domestic country to foreign destinations. The former has an important implication for monetary policy due to the relevance of changes in import prices on the inflation rate and its forecast; that is, low exchange rate pass-through into import prices (and consumer prices) means depreciation of the domestic currency need not lead to substantial inflation in the short-run and thereby need not strongly influence inflation forecasts by the central bank. The latter which is covered in one of the papers in the dissertation, focuses on exporters’ pricing behavior in reaction to changes in exchange rates, which would be reflected in the prices of the currencies in destination markets. The effects of exchange rate changes on export prices are reflected in exporter profits, which in turn can affect employment and wages in the export industries.

There are two ways of understanding exchange rate pass-through. One is with respect to changes in prices of domestic exports in the domestic currency and the other regards prices of those exports in destination markets in the local currencies, which are two sides of the same coin. If an appreciation of an exporting country’s currency is fully reflected in the export price in the exporter’s currency, pass-through to the export price is described as complete or full. If only a fraction of the appreciation is reflected in the export prices, then pass-through is said to be incomplete or partial. If no changes are mirrored into the export price, there is no pass-through. Exchange rate pass-through of exports price in the exporter’s currency being complete is another way of saying that there is no exchange rate pass-through (no change in prices) in the export price in terms of the importer’s currency. For example, with a 10% appreciation of the domestic currency against a foreign counterpart, if a domestic exporter decreases the prices of its export in terms of the domestic currency by 10% (complete pass-through in the export price), then it would result in no change in the price of that export in the foreign currency (zero pass-through in the import price). If instead the exporter does not change the price of its export in terms of the domestic currency (zero pass-through in the export price), it would then make the price of its export in the foreign importing market rise by 10% (complete pass-through in the import price).

5 The relationship between exchange rates and inflation has been receiving attention within the “new open macroeconomics” which is based on Obstfeld and Rogoff (1995) (Taylor, 2000; Choudhri and Hakura, 2001; and Devereux and Engel, 2003 among others).
There is ample empirical evidence that neither export prices nor import prices respond proportionately to exchange rates (Hooper and Mann, 1989; and Feenstra, 1989; Parsely, 1993 among others).

2.3. Pricing-to-market (PTM)

Incomplete pass-through into export prices (which also means incomplete pass-through into import prices) can be explained by the pricing behavior of exporters referred to as pricing-to-market (PTM) (a concept developed in Krugman, 1987). PTM explains incomplete pass-through by price discrimination of monopolistically competitive firms in segmented markets where arbitraging opportunities are not exploited. In such a setting, charging different prices for different destination markets is possible. Empirical studies on PTM have shown that the extent of PTM depends on the firm’s markup adjustment (Dornbusch, 1987; Krugman, 1987; Knetter, 1989; 1993; Marston, 1990; Engel, 1993 among others). Put differently, a markup would be constant if firms are fully reflecting the exchange rate movements into the prices at the destination currencies, in which case there is no PTM. However, markup would change if their export prices are only partially passed-through into importers’ currency, leading PTM to happen (Bailliu and Bouakez, 2004).

The earlier studies on PTM were based on a partial equilibrium framework. PTM started to be dealt with in the general-equilibrium framework later as an extension of the Redux model (Obstfeld and Rogoff, 1995). The assertion that the law of one price always holds in the original Redux model (Obstfeld and Rogoff, 1995) was challenged by Engel (1999) and others who have documented that deviations of prices of tradable goods in the international market can be attributed to real exchange rate fluctuation to a large extent (Lane, 2001). With empirical evidence supporting international market segmentation, PTM was introduced by Betts and Devereux (1996) into the

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6 The market for automobiles is an example of market segmentation, with identical products having different prices in different locations due to the effects from geography or nationality of products. Automobiles imported into a foreign destination would be levied additional taxes or requested to follow safety and environmental regulations which do not comply with those of the home market. Additionally, warranties and service are more linked to the location of purchase than the location of production (Goldberg and Knetter, 1997).
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*Redux* model assuming that prices of the internationally traded goods are set in advance in the currency of the destination market; i.e. prices of imports do not vary in terms of the importing country’s currency even though the nominal exchange rate of the exporting country’s currency against importing country’s currency fluctuates. The static version of the model in Betts and Devereux (1996) developed into a dynamic model in Betts and Devereux (2000) where a fraction of firms can set different prices at home and at foreign destinations. This assumption, known as local currency pricing, causes deviations from the law of one price in the event of a shock; for example, if a monetary shock in the importing country induces change in the value of its currency, import prices in terms of its country would still be the same (note that their import prices were set in their own currency by exporters) resulting in zero exchange rate pass-through to their import prices.

Estimates from empirical studies on exchange rate pass-through and pricing-to-market have shown that the degree of price changes due to exchange rate movements varies by industry and by country with a general conclusion that local prices of imported goods do not fully respond to the importing market’s currency appreciation or depreciation (Goldberg and Knetter 1997; Campa and Goldberg 2002; and Anderton 2003). The fact that prices of imported goods are not fully responsive to exchange rate movements, which translates to more pass-through to export prices in the exporter’s currency, has very important implications for profitability of export industries.
3. Theoretical frameworks for exchange rate determination

In this section the main features of five macroeconomic models of exchange rate determination are described, focusing on the relationship between exchange rates and interest rate differentials, thereby providing the theoretical foundations for the first paper of this dissertation. The five models covered are the flexible-price monetary model, the Mundell-Fleming model, the sticky-price monetary model (or overshooting model), the portfolio-balance model, and the Obstfeld and Rogoff (1995) Redux model. Different assumptions in the theoretical models of open-economy macroeconomics have previously led to dramatically different conclusions on various economic relationships, and often these differences have hinged on the assumed or derived relationship between the exchange rate between two countries and the interest rate differential between those countries. The legitimacy of the relevant assumptions has frequently been associated with the time scale we are considering – the long-run, in which product prices are perfectly flexible, or the short-run in which this is not the case.

3.1. The flexible-price monetary model

The flexible-price monetary model is based on three major assumptions: 1) the aggregate supply curve is vertical at an economy’s natural output level, 2) domestic money market equilibrium depends on only a few domestic macroeconomic variables (fundamental variables including money supply, real income and nominal interest rate), and 3) relative purchasing power parity (PPP) obtains at all times. The first and third assumptions presuppose perfect price flexibility in all markets, and the second assumption regards that there is a one-for-one relationship between money supply and the price level at a given real income. The third assumption, relative PPP, also presupposes frictionless trade of all goods and services between countries.

The flexible-price monetary tradition tends to indicate there should be a positive relationship between the interest rate differential and the exchange rate.

7 Monetary models, for which there are flexible-price and sticky price versions, view that exchange rates move to equilibrate the international demand for stocks of assets rather than the international demand for flows of goods (Frankel, 1979).
Introduction to the thesis

or the change in that exchange rate, which can be explained in two ways. First, an exogenous increase in the home country’s interest rate (not due to money supply reduction), all else equal can drive down money demand in that country and drive up its aggregate demand, resulting in higher prices in that country, and through relative purchasing power parity the exchange rate will rise (the home country’s currency depreciates against the foreign country’s currency). “Relative purchasing power parity” refers to having a constant real exchange rate, i.e. \( EP^*/P \), where \( E \) is the exchange rate (the price of foreign currency in terms of domestic currency), \( P^* \) is the foreign price level, and \( P \) is the home country’s price level. Relative purchasing power parity is equivalently defined as having the rate of change in the exchange rate equal to the home country’s price inflation minus the foreign country’s price inflation.

Second, assuming perfect foresight (so expected inflation and actual inflation are equivalent) an increase in the inflation in the home country all else equal tends to lead to both (1) a rise in the rate of depreciation of the home country’s currency due to relative purchasing power parity and (2) a rise in the nominal interest rate via the Fisher (1930) hypothesis, which asserts that any increases in expected inflation of country should, all else equal, be matched by an increase in that country’s nominal interest rate.

Theoretically changes in the market’s expectation regarding future values of the fundamentals in the monetary models can cause the future outlook for exchange rates to change, which, in turn, causes instantaneous fluctuations of the currency values. This type of feedback mechanism (e.g. if the price of an asset is expected to rise at some point in the future, the rise occurs right now) is explained in news models by assuming rational expectations (Copeland, 2008).9

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8 Suppose that money demand is of the Cambridge form \( M^d = kPY \), where \( M^d \) is money demand, \( P \) is the aggregate price level, \( Y \) is real national income, and \( k \) is a variable which is a negative function of the interest rate (a higher interest rate increases the opportunity cost of holding money). Setting money supply equal to money demand and solving for \( P \) we get \( P = M^d/(kY) \), which acts as an aggregate demand function. An increase in the interest rate, all else equal, causes \( k \) to drop and \( P \) to rise.

3.2. The Mundell-Flemming (M-F) model

The Mundell-Flemming model made a major advance in exchange rate modeling in the early 1960s (primarily by Mundell, 1961, 1962, 1963 and Flemming, 1962). The Mundell-Flemming (M-F) model extends Keynesian analysis 10 by specifying the external sector of the economy. 11 With international capital mobility, the consequences of policy actions are associated with how the capital account in the balance of payments is related to the domestic interest rate, a relationship which is included in an open economy version of the IS-LM model using an additional curve indicating where the balance of payments equals zero. In the M-F model, the effect of an initial policy action and its subsequent adjustment depends on the degree of capital mobility. In the case of high international capital mobility, the decrease in the interest rate of the home country due to it having a monetary expansion or fiscal contraction leads to an incipient deficit in the balance of payments at the original exchange rate due to a potentially massive capital outflow from the home country. Therefore, there is an excess demand for foreign currency at the original exchange rate, so the home country’s currency depreciates. That depreciation leads to an increase in the trade balance for the home country, which in turn means that aggregate demand in the home country increases so the home-country interest rate increases and the capital account does not drop as much as it would otherwise. In this model a negative relationship between the interest rate differential and the exchange rate is apparent – the interest rate falls and because of that the exchange rate rises (i.e. domestic currency is depreciated in a given definition of exchange rate as units of domestic currency per foreign currency). 12

10 As in the Keynesian tradition, the M-F model draws a clear distinction from the flexible-price monetary model in two respects: 1) the aggregate price level is assumed to be fixed; and 2) the aggregate supply is horizontal at the fixed price level.

11 The very early Keynesian approach to exchange rate determination largely focused on the role of elasticities of demand for and supply of exports and imports along with the demand for and supply of foreign currency, which is referred to as the elasticity approach formalized by Marshall (1923) and Lerner (1936).

12 The sign of this causal relationship in the short-run does not change based upon whether the initial shock is contractionary or expansionary.
3.3. The sticky-price monetary model

The sticky-price monetary model (also known as the Dornbusch overshooting model due to the original formulation by Rudiger Dornbusch, 1976) combines both the features of the M-F model and the flexible-price monetary model. It demonstrates what happens between the sticky-price short-run and the flexible price long-run by considering two markets – the financial market and the goods market – which have different adjustment speeds. The price-stickiness in the goods market in the short-run is compensated by the variables in the financial market – exchange rates and interest rates – which adjust instantaneously. As a result, those variables in the financial market tend to over-adjust in response to monetary market disturbances in an expectation that their long-run equilibrium levels will be restored when adjustment in the goods market takes effect. For example, a monetary expansion at home reduces the interest rate in the short-run, which results in the exchange rate rising immediately, beyond its new higher long-run level. A short-run equilibrium is achieved where the interest rate differential compensates the expected depreciation following the monetary shock, i.e. the uncovered interest rate parity (UIRP) condition holds. The UIRP condition is

$$ R - R^* = \frac{E^e}{E} - 1, $$

where $R$ is the domestic interest rate, $R^*$ is the foreign interest rate, $E$ is the spot exchange rate (units of domestic currency per foreign currency), and $E^e$ is the expected future exchange rate (the long-run exchange rate in this model). Keeping $R^*$ and $E^e$ constant, a drop in $R$ needs to be offset by a rise in $E$ to maintain the equality, which shows the basis of the short-run negative relationship between the interest rate differential and the exchange rate found in many sticky-price models. After a permanent one-time monetary expansion in the Home country, $E$ rises due to both $R$ dropping and $E^e$ rising. During the adjustment process (between the short-run and the long-run), prices rise, decreasing the real money supply and increasing $R$, which must be accompanied by $E$ declining to maintain equation (4). Thus what appears in this model is a negative relationship between $R - R^*$ and $E$ in an immediate short-term, and that negative relationship is sustained between the short-run and the long-run. However, in the long run for the Dornbusch model, one-time monetary shocks to the level of money supply or money demand have no effect.
on the interest rate differential so any long-run relationship between the interest rate differential and the exchange rate at that time scale cannot be induced.

3.4. The portfolio balance model

There are two noticeable differences between monetary models and the portfolio-balance models. Firstly, monetary models assume perfect capital substitutability and no risk premium, whereas the portfolio-balance models are based on imperfect substitutability between domestic and foreign assets. Secondly, in monetary models the assumption of risk-neutral agents leads to a zero-risk premium while portfolio-balance models require a positive risk premium to persuade risk-averse agents to hold risky assets. This difference in the risk premium results in uncovered interest parity holding in monetary models but not in the portfolio-balance models. In the portfolio-balance approach, agents allocate their wealth among different assets—domestic money, domestic bonds and foreign bonds for example. Exchange rates play a role in balancing asset demands and supplies.

A reduction in the return on assets in the home country in portfolio balance models (due to a monetary expansion, say) will initially result in capital flows out of that country, but unlike in Mundell-Fleming, those capital flows stop once investors have adjusted their portfolio shares to make the optimal trade-offs between risk and return. This situation again leads to a depreciation of the home country’s currency – the same reaction as in Mundell-Fleming and through the UIP condition in the Dornbusch model. After the initial depreciation in portfolio balance models, the home country collects foreign assets due to the depreciation-induced current account surplus (assuming it started with a current account equal to zero). Between the short-run and the long-run, two adjustments are occurring. First, the home-country’s goods prices are rising, reducing the competitiveness it gained through the depreciation. Second, the home country’s currency appreciates since the home-country investors’ value foreign assets less considering they collected a lot of them already through the short-run current account surplus. Also the currency of the home country appreciates sufficiently to support a long-run home-country

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13 A portfolio balance approach to macroeconomic modeling was developed by Metzler (1951) and Tobin (1969), which has been further developed by Branson (1983), Branson and Halttunen (1979) and Branson, Hattunen and Masson (1979). The portfolio balance model in this subsection is based on the presentation on portfolio balance model in Copeland (2008) which follows Branson and Henderson (1985).
current account deficit funded by interest collected on the earlier collected foreign assets from the short-run current account surplus. As in the Dornbusch model, there is overshooting of the exchange rate which ends up higher than initially, but the adjustment process does not include a change in the interest rate.

3.5. The Redux model

A distinguishing feature of the Redux model among the other exchange rate determination models is that in the Redux model exchange rate is determined in the context of dynamic general equilibrium models with explicit microfoundations, short-run nominal rigidities and imperfect competition (Sarno and Taylor, 2004). The models described so far can be termed as ‘traditional’ models compared to the models within ‘new’ open macroeconomics. The Redux model, introduced by Obstfeld and Rogoff (1995), is the baseline model for those in the new-open macroeconomic tradition, dealing with two countries, monopolistically competitive industries, sticky prices (for some prices), and an intertemporal approach to the current account balance. Each country consists of households who play a dual role in the economy, i.e. they are consumption units with identical utility functions; and they produce differentiated goods and have the monopoly power. There is no barrier to trade, thus the law of one price holds for each good, leading to purchasing power parity holding. Uncovered interest rate parity holds also along with real interest rate equality. Prices are sticky in the short-run and output is demand driven. The impact of a shock in the short-run is distinguished from the steady-state (long-run) effect.

The effect of a permanent one-time increase in money supply, in a surprise setting, was analyzed in the Obstfeld and Rogoff (1995). To put the conclusion first, the exchange rate simply jumps to a new steady-state level right after the monetary shock even though prices are fixed in the short-run, i.e. no overshooting occurs, which is unlike what occurs in the Dornbusch overshooting model. This result basically arises from the constant relative consumption between the countries (based on Euler equations) being the same in the long-run as in the short-run due to consumption smoothing over time, which is expected to remain in the future. The monetary shock in their paper is

14 This is a small open-economy version which allows 1) international transmission channels; and 2) interest rate and asset prices that are endogenously determined (Sarno and Taylor, 2004).
Introduction to the thesis

assumed to be once-and-for-all, with the relative price levels between Home and Foreign thus remaining constant in the long-run. Due to the purchasing power parity, the constant relative price is possible only if the exchange rate is expected to be unchanged at the new steady-state level. All the variables will be at the steady-state level in the long-run, and the exchange rate must be at that level in the short-run after a shock. Within the appendix of Obstfeld and Rogoff (1995), an alternative small open economy model with nontraded consumption goods is presented, and that model does have the possibility of exchange-rate overshooting, with the $E$ increasing beyond a new higher long-run steady-state level in reaction to a domestic money-supply increase. Lane (2001) notes that that overshooting is associated with a lowered short-run nominal interest rate.

The fixed price assumption in the original Obstfeld and Rogoff (1995) model which regards only the domestic currency price (while that the price of domestic products sold in the foreign market changes immediately according to LOP given exchange rate movements) can be explained by the economic notion of menu costs. However, it raises the question of the asymmetric application of menu costs by having them relevant only in the domestic market. Betts and Devereux (2000) adjusted the original Redux model by assuming firms can set different prices in home and foreign markets, and found that under such circumstances a monetary expansion could lead to short-run exchange rate overshooting. This can be explained by the pricing-to-market behavior of firms which make the expenditure-switching effect vanish, leading to smaller effects on consumption, thereby increasing the size of the required exchange rate movements to meet the monetary equilibrium (Lane, 2001).15

The relationships between the exchange rate and the interest rate differential within the macroeconomic exchange rate determination models discussed throughout this section are summarized in table 1.

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15 The assumption of the Obstfeld and Rogoff (1995) that prices are sticky in producer’s currency is called producer currency pricing (PCP) while that of Betts and Devereux (1996, 2000) is called local currency pricing (LCP). The issue of whether price setting is based on PCP or LCP has important implications for monetary and exchange rate policy (Choudhri, Fruqee, and Hakura, 2005). Along with the low-inflation environment in many industrialized countries, coinciding with several episodes since the 1990s, most recent studies examine the link between ERPT and monetary policy in dynamic general equilibrium models (Taylor, 2000; Choudhri and Hakura, 2001; Devereux and Yetman, 2003; and Devereux, Engel, and Storgaard, 2003 among others).
### Table 1: Relationships between interest rate differential (\( R - R^* \)) and the exchange rate (\( E \)) suggested by various exchange rate determination models

<table>
<thead>
<tr>
<th>Model</th>
<th>Short-run</th>
<th>Adjustment Process</th>
<th>Long-run</th>
</tr>
</thead>
<tbody>
<tr>
<td>Money demand effect</td>
<td></td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>Fisher effect</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mundell-Fleming model</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dornbusch model</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Portfolio Balance model</td>
<td>-</td>
<td>E reverses direction of movement found in the short-run</td>
<td>-</td>
</tr>
<tr>
<td>Redux model</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Small country, nontraded goods (Obstfeld and Rogoff, 1995)</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Pricing to market (Bett and Devereux, 2000)</td>
<td>-</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4. Asset pricing models, exchange rate exposure, and time varying parameters

The third paper of this dissertation deals with a multifactor asset pricing model which considers exchange rate exposure and includes time-varying parameters. This section provides a discussion on closely associated literatures to indicate where that paper fits in as a contribution.

Cell (1) of table 2 includes literature on estimating a beta of a stock with respect to the overall market in the single factor capital asset pricing model (CAPM), as developed by Sharpe (1964), Lintner (1965) and Black et al. (1972). Beta measures the systematic risk, i.e. the sensitivity of a stock’s return to the market index, which determines the required rate of return on equity (i.e. the cost of equity for the firm). The early literature on the CAPM has one factor — the rate of return on the market portfolio above the “risk-free” rate of return — linearly related to the stock’s rate of return above the “risk-free” rate of return. The CAPM is a cornerstone of modern finance with beta representing one of the most widely used concepts in finance. However, the original form of the CAPM, with a single constant beta, has been questioned by several empirical studies.

Cell (2) deals with empirical studies that, as a theoretical extension, include additional sources of risk, i.e. multifactor models. One of these is the international CAPM, which considers exposure to exchange rate changes as an additional source of risk (Solnik, 1974; Stulz, 1981; and Adler and Dumas, 1983). Exchange rates can have a very important role on the pricing behavior of assets.

16 Other theoretical extensions of the CAPM, not covered in this review, include 1) after-tax CAPM in which investors must be compensated with higher pre-tax returns due to higher taxes imposed on high dividend-yield stocks; 2) the inter-temporal CAPM in which investors are concerned not only with their end-of-period payoff, but also their wealth at time $t$, which might vary depending on labor income, the prices of consumption goods, and expectations about them; 3) and the consumption CAPM (C-CAPM) in which the risk in future consumption is the only one risk.

17 If purchasing power parity (PPP) does not hold continuously in an international context, any investment in a foreign asset requires consideration of the performance of the domestic currency relative to the foreign currency along with the foreign currency performance of the foreign asset. Stulz (1995) includes a survey of empirical studies.
and profitability of exporting and importing firms. Industries or firms differ in the extent to which they pass through the changes in the exchange rates into the prices of goods sold in the foreign markets and, thus, they also differ in their exchange rate exposure – the responsiveness of firms’ profitability to changes in exchange rates. In less competitive industries where products are differentiated, prices are set higher than marginal cost implying higher mark-ups. Firms in such industries that have abilities to absorb the effect of changes in exchange rate by adjusting profit margins and lowering pass-through into import prices (Dominguez and Tesar, 2006). However, in more competitive industries where products are homogenous, pass-through is found to be higher (Bailliu and Bouakez, 2004). Exposure to exchange rate changes thus can be posited as depending on certain characteristics of an industry, such as the amount of competition, share of foreign sales, international asset holdings, and substitutability in using domestic and foreign inputs (Shapiro, 1975; Bodnar and Gentry, 1993). Whether changes in exchange rates have measurable effects on firms or industries has been documented in the literature on exchange rate exposure. The regression slope coefficient from regressing the real value of the firm on the exchange rate was defined as exposure to exchange rate movements from the early works by Dumas (1978) and Adler and Dumas (1983). From a U.S. investor’s point of view with domestic inflation being non-random, exposure is measured by the slope coefficient from a linear regression of the dollar value of the firm on the exchange rate (Jorion 1990). While weak evidence of systematic exchange rate exposure has been reported in some empirical studies (Jorion, 1990; Bartov and Bodnar, 1994; Griffin and Stulz, 2001; Doidge et al., 2003 among others), other existing literature on the relationship between international stock prices has found that that exchange rate movements do matter for profitability as measured by stock returns (Choi and Parasad, 1995; Dominguez and Tesar, 2006).18

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18 The finding that exchange rate movements have a significant fraction of profitability of the firms, however, depends on the specific exchange rate (trade-weighted or bilateral exchange rates) and varies over time (Dominguez and Tesar, 2006).
Table 2. Categories of literatures in asset pricing models

<table>
<thead>
<tr>
<th></th>
<th>Constant</th>
<th>Time-varying</th>
</tr>
</thead>
<tbody>
<tr>
<td>One-(\beta)</td>
<td>(1) e.g. Sharpe (1964), Lintner (1965), Black et al. (1972)</td>
<td>(3) e.g. Fabozzi and Francis (1978), Bos and Newbold (1984), Mergner and Bulla (2008)</td>
</tr>
</tbody>
</table>

Regarding multifactor models, the article by Fama and French (1992), in particular, has received a lot of attention and has led the propagation of multifactor models including Fama-French type factors. The three-factor model in Fama and French (1992, 1998) illustrates that the multi-factor model captures most of the average-return anomalies missed by the CAPM, thereby providing a better description of average returns than the CAPM.19

Another line of empirical studies, those belonging to cell (3), have questioned the validity of the beta stability assumption (Fabozzi and Francis, 1978; Sunder, 1980; Bos and Newbold, 1984; Collins et al., 1987). These empirical studies generally reject that assumption, adopting instead methodologies which update expected returns or volatility conditioned on the most recent past information. Frequently used methodologies are GARCH, GARCH-in-means, and the Kalman filter for studying time-varying systematic risks (Fernandez, 2006). Allowing for betas to vary over time not only removes the need for assumed linearity in asset price modeling but also accounts for the possible effect of omitted variables (Gonzalez-Rivera, 1997).

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19 The three-factor model captures that cross-sectional variation in average stock returns associated with market beta, size, and book-to-market equity. There were counter-arguments to the three-factor model by Kothari, Shanken, and Sloan (1995) based on the following two claims: 1) using betas estimated from annual returns produces a stronger positive relation between average return than using monthly returns, and 2) the relation between average return and book-to-market equity Fama and French (1992) and others is exaggerated due to survivor bias in the sample used.
Cell (4) in table 2 presents studies that investigate asset pricing with multiple risk factors and time-varying betas. Dumas and Solnik (1995) were supportive of including foreign exchange risk by using a conditional approach that allows for time variation in the sensitivities of returns to exchange rate risk and a global portfolio. Consistent with the results of Dumas and Solnik (1995), Santis and Gerard (1998), Santis et al. (2003) and Zhang (2006) also support a model which includes both the market and exchange risks in a conditional version of the international CAPM. The third paper of this dissertation, which estimates time-varying market risk and exchange rate exposure parameters, also fits in the literature category presented in cell (4).

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20 The existing literature on the relationship between stock prices and exchange rates, however, provides inconclusive results or only weak evidence of systematic exchange rate exposure. Overall, the evidence from empirical studies considering exchange rate risk suggests that it is marginally more important in open, export-oriented economies (Bartram and Bodnar, 2007).
5. Interdependence among national stock markets

The theoretical basis for studies on short and long-run relationships among stock markets lies in information efficiency of the integrated market. Since integrated markets contain information on the common stochastic trends, market predictability can be enhanced by using the information contained in other stock markets.\(^{21}\) Another important aspect within the context of market integration and interdependence is that assets associated with similar levels of risk in different countries should also lead to a similar level of return (Masih and Masih, 1999). Empirical studies addressing this issue, however, have provided inconsistent results (Errunza and Losq, 1985; Wheatly, 1988).\(^{22}\)

The integration and interdependence of the world’s equity markets is consistent with modern portfolio theory’s conclusion on the issue of diversifying assets. This theory justifies investors’ diversification of their assets across national borders if the domestic stocks have imperfect correlation with foreign stocks. The advantages of asset diversification have been studied in extensive literature which quantifies the risks and benefits of diversifying assets internationally (Solnik, 1991). Mashi and Mashi (2001) point out that this issue is closely related to the phenomenon that stock prices across national borders tend to move together. The worldwide impact of the 2008 stock market crash highlighted how integrated world equity markets are, and a stronger co-movement among world equity markets has been an important concern for market stability and international diversification (Chowdhury, 1994; Dekker et al., 2001).

While the above-mentioned interrelationships of equity markets have a short-run empirical basis, long-run relationships have also been investigated as well using the notion of cointegration (Engle and Granger, 1987) with recognition of the nonstationary property of stock prices. Empirical findings

\(^{21}\) However, some empirical works view that cointegration does not necessarily imply anything about efficiency (Dwyer and Wallace, 1992; Masih and Masih, 2001; 2002).

\(^{22}\) Wheatly (1988) argues that assets that are diversified internationally could be “mean-variance efficient even without market integration”.

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from this branch of study are mixed, with some studies reporting no cointegration (Chan, Gup, and Pan, 1992; DeFusco, Geppert, and Tseksekos, 1996) while other studies finding evidence of long run interdependence (Chung and Liu, 1994; Arshanapalli, Doukas, and Land, 1995; Masih and Masih, 1999 among others). The findings from studies that investigated long-run relationships have important implications for diversification potential in international stock markets by providing information on the degree to which national stock markets are integrated.
6. Outline of the papers and summary of main findings

Paper 1: Exchange rate fluctuations and markup adjustments: Cases of manufacturing products exported from South Korea

The relation between exchange rate fluctuations and export prices is a matter of crucial concern to South Korea for which economic development in the past four decades has been led by export growth. This concern has increased after independently floating exchange rates were adopted in December, 1997. Investigation into differences in markup adjustment across different Korean exports would suggest its association with welfare distribution. Varying responses of industries producing different goods to exchange rate fluctuations causes asymmetric effects across industries not only on price but also on the welfare of workers who are producing the goods as profit variations can affect employment and wages. Therefore, exploring the effects of exchange rate movements across groups of exports is a matter of great importance in South Korea.

The empirical work of this paper intends to add to the literature on exchange rate pass-through by investigating (1) the degree of pass-through to Korean export prices and (2) the variation of pass-through across major destinations of South Korean products. Export unit price (value over quantity) is used as a measure of the export price. This study uses annual data on value and quantity of exports for seven leading Korean export commodities. There are ten major destination markets dealt with which were chosen based on two criteria: 1) whether there was a sizable volume of exports during the sample period and 2) whether destination markets were common in terms of the export volume for each commodity group. A specific type of pricing-to-market (PTM), so-called ‘local-currency price stabilization’ which stabilizes the import prices by reducing markups in time of exporter’s currency appreciation is found

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23 The South Korean currency (won) was pegged to the US dollar until 1979; multiple currency basket peg system during 1980s; market average exchange rate system from 1990 to 1997; independently floating system since Dec. 1997(with no daily band).
to be a dominant strategy in the long-run. In the short-run, Korean exporters respond more by absorbing the effects of exchange rate change into their export prices in Korean currency. There is often reversal of at least some of the short-run adjustments between the short-run and long-run. Overall, the PTM coefficients, representing how much won prices of exports decrease in response to a won appreciation, are typically larger in developing economies and for the machinery export commodity groups.

**Paper 2: The relationship between exchange rates and interest rate differentials: A wavelet approach**

Different assumptions in the theoretical models of open-economy macroeconomics have previously led to dramatically different conclusions on various economic relationships, and often these differences have hinged on the assumed or derived relationship between the exchange rate between two countries and the interest rate differential between those countries. The legitimacy of the relevant assumptions has frequently been associated with the time scale we are considering – the long-run, in which product prices are perfectly flexible, or the short-run in which this is not the case. In this paper, wavelet decomposition is employed as an empirical methodology to help consider time-scale issues in studying the relationship between the exchange rate and the interest rate differential. In so doing, this paper lends itself to an understanding of the time-varying relationship of the two given variables, an issue which has not been addressed thoroughly in previous empirical studies.

Among the data used in this study are monthly and quarterly spot exchange rates against the Swedish krona of five major currencies (the U.S. dollar, the Japanese yen, the euro, the pound sterling, and the Swiss franc) and two other currencies (the Norwegian krone, and the (South) Korean won). The starting month of the sample period varies for each currency depending on the availability of data in the floating period of the exchange rate. For the Swedish krona the sample period starts from January, 1993; for the Korean won January, 1998; for the euro January, 2000; and for the Swiss franc May, 2000. The sampled periods are covered up to May, 2009.
An additive decomposition on each of the time series through wavelets based on filtering using the Haar (1910) function is performed in this paper. A quick way to calculate the wavelet coefficients is through a methodology introduced by Mallat (1989) referred to as multiresolution analysis (MRA), which also conveniently provides a rather intuitive interpretation of the wavelet decomposition. Briefly, it is simply a matter of finding averages (means, perhaps weighted) and differences from those averages, starting with values in the series closest to each other—the lowest scale—and repeating that process with the previous average series, gradually expanding how much of the original data is included in each successive average, i.e. increasing the scale.

The results of the regression analyses in the wavelet domain show that the relationship between the variables of interest tends to be negative at the shorter time horizons, at wavelet scales of a half year or less, while a positive relationship tends to be observed in the longer horizons over a year. The results when using the two different data frequencies—monthly and quarterly—are consistent with each other in this finding.

Exploring the relationship between the exchange rate and the interest rate differential involves dealing with the issue that prices tend to move more slowly over shorter time scales, and that is why there have been broadly two theoretical approaches in explaining the relationship. The key findings of this paper are consistent with the theoretical underpinnings of both sticky-price and flexible price exchange-rate determination models following an asset approach; the former predict a negative relationship between the exchange rate and the interest rate differential in the short-run with price stickiness, while the latter claim a positive relationship in the long-run with the flexible movement of the price levels.

Overall, the time-scale decomposition of the exchange rates and the interest rate differentials provides insights to the testing of the relationship between these variables at different time scales. Puzzles and failures of previous empirical findings on relationships which have a strong time scale element have a possibility of being resolved and further explained by wavelet analysis.

**Paper 3: Time-varying sensitivities of sectoral returns to market returns and exchange rate movements**
How to assess the risk of the cash flow from a project or a financial asset is one of the most important research questions posed in finance. It has been generally agreed that with riskier assets a higher expected return for investment is demanded. However, determining the riskiness of investment, and knowing the required rate of return on a risky investment is still no easy question to answer, with competing theories on the subject. Moreover, considering risk in an increasingly more global equity market is very difficult because globalization increases the number of factors to consider. To improve understanding of the benefits and drawbacks of international investments, we need to consider what determines risk and return in international equity markets, which necessitates understanding of how currency fluctuations affect international investments.

The objective of this paper is to investigate the time-varying behavior of conditional betas of the industry returns in the US stock market to market returns and to exchange rate movements. These betas, measuring sensitivities, are measured for various industries at the supersectoral level for the 1995–2010 period and are measured at different time horizons.

The nominal exchange rate variable used in this paper is the foreign currency value of a US dollar, where the foreign currency is composed of the multilateral trade-weighted currencies of a large group of major US trading partners (the nominal effective exchange rate, NEER). For the market returns, the total return (i.e. with reinvested dividends) series of the MSCI ACWI (All Country World Index) are used. The MSCI ACWI is a market capitalization weighted index that is constructed by aggregating equity market performance from developed and emerging markets.

The empirical findings, in general, can be summarized into five points. First, during financial crisis periods based on a crises starting in the US, the market risk tends to rise. The degree of the change in market risk, however, is typically stronger in those sectors most closely associated with the crisis. Specifically, it is the Technology sector which showed a soaring market beta during the dot-com bubble burst in the year 2000, while the market beta of the Automobile & Parts sector and Financial industry rose sharply during the 2008-2009 subprime financial crisis. These rises in market risk can be explained as being due to investors perceiving a rise in stock market volatility during a crisis period as an increase in the risk of equity investment, which in turn makes the time-varying betas of the sectoral returns to the market rise. Also those sectors most closely associated with a crisis are likely to be the biggest contributors to market
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movements during the crisis, so it is not surprising that their measured market risk is substantially higher at such times.

Second, there appears to be a positive relationship between an industry's return and the value of the dollar when using the exchange rate risk at the daily return interval. Such a finding is counter to the general notion that a US dollar appreciation would cause a loss of competitiveness for dollar-denominated exports. The positive relationship could be due to the existence of a reverse relationship, i.e. with the growing returns in a US industry putting upward pressure on the dollar.

Third, during the subprime financial crisis the relation between excess returns and the exchange rate tended to fall. This was also the case for the Technology sector during the dot-com bubble burst. Notably during both the dot-com bubble burst and the subprime mortgage crisis the dollar was appreciating while returns fell, an opposite relationship from that found in the previous paragraph. An explanation for this is that an international financial crisis tends to put downward pressure on returns and can put upward pressure on the dollar as investors consider it a safe-haven—even if the US is at the center of the financial crisis.

Fourth, it is observable that the market risks shrink over longer time-horizons. To explain this finding we can resort to the association of time scales and risk appetite of investors. Arguably, short-term investments more typically use short-term (high-frequency) signals for profit and are thereby accompanied by high market risk, while the longer-term investments are supposedly based more on fundamental information, thus bearing less market risk.

Fifth, the estimated relationship between excess returns and the exchange rate appear to be declining with longer time horizons, in some cases resulting ultimately in a negative relationship between the US dollar and the industry returns. This is consistent with the idea that the effect of a US dollar appreciation on reduced competitiveness of US exports becomes stronger with the longer time horizons.

Paper 4: Price linkages of the East Asian stock markets in different time horizons

This study focuses on two aspects of equity market linkages: 1) the price linkages of the US and the Asian equity markets (China, Hong Kong, Japan, Singapore, Korea, and Taiwan); and 2) the linkages among the Asian markets
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themselves. Regarding the first, the leading role of the US market in the international stock market has been documented in numerous studies.

The data employed in this study are MSCI price index data, expressed in US dollars, for six Asian markets—the People’s Republic of China, the Republic of Korea (South Korea), Taiwan, Japan, Hong Kong, and Singapore—and the United States of America obtained from Thomson Financial Datastream for the sample period November 8, 1996 to June 16, 2009. MSCI indices are employed widely in the financial literature due to the degree of comparability and avoidance of dual listing (Roca, 1999; Cheung and Lai, 1999 among others). The sample period is divided into five sub-periods: 1) before the Asian financial crisis (November 1996 – May 1997); 2) the Asian financial crisis (July 1997 – June 2000); 3) the dot-com bubble bust (July 2000 – June 2002); 4) the inter-crisis period (July 2003 – June 2007); 5) the subprime financial crisis (July 2007 – June 2009).

Previous studies have used first differences of the stock prices or differences in logged stock prices in keeping with the rationale provided by Fama (1965) to better deal with nonstationarity. This study utilizes the log of the price indices with wavelet analysis. This allows avoidance of information loss that first-differencing entails. The nonstationarity in the price index level that typically would be a problem for OLS estimation is not a problem for wavelet analysis.

Testing for Granger causality is performed for each country pair. Granger causality at each wavelet scale is tested by using wavelet details for the price indices of the national stock markets. The findings of the paper can be summarized as follows. The major equity markets in the East Asian region are closely integrated, thereby diminishing the potential for Asian portfolio diversification. The equity market of Japan, however, is less integrated than the other equity markets in the region. What is the most influential market in the region varies in different sub-periods: at the finest time scale of 1-2 day movements of the stock price indices, two Asian equity markets, Singapore and Hong Kong, led the equity market in the region by the late 1990s (Singapore before the Asian financial crisis, Hong Kong after); while the US equity market has been the most influential markets through the dot-com bubble bust, inter-crisis, and the subprime mortgage crisis periods. Also at this finest time scale, the causal linkages of the US equity market to the Asian equity markets does not have notably different patterns depending on whether it is a crisis period or

24 The available data series range back to October 17th, 1989. However, the sample period could not cover the early five years from the available data set due to the methodology, discrete wavelet transform (DWT), used in this paper.
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not. The influence of the US equity market is much less at larger time scales throughout all sub-sample periods. The leading role of the US equity market substantially weakens while the interdependence among the Asian equity markets is stronger at longer time scales of 8 to 16 days. This evidence suggests that the information coming from outside of the region initially causes very short-run responses of the Asian equity markets, then the adjustment process of each Asian equity market to the initial information affects equity market movements across the region. A general finding is that not only is it true that the number of causal relationships among the equity markets in this study varies across scales, but that the direction of causality differs by time scales.
References


