THE REAL EXCHANGE RATE MISALIGNMENT AND ECONOMIC PERFORMANCE IN EAST ASIAN ECONOMIES

A dissertation submitted by

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For the award of

Doctor of Philosophy

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August 2015

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ABSTRACT

This thesis investigates the effect of the real exchange rate (RER) misalignment on economic growth in East Asian economies. It has two main components. The first part offers a theoretical two-sector small open economy model and theoretically explains for the investment channel through which undervaluation could promote economic growth. The finding is that a depreciation in the RER results in higher steady state levels of capital stock and investment. Moreover, a depreciation in the RER increases the optimal investment rate associated with any initial capital stock.

In the second part, data collected from nine East Asian economies over the recent three decades are used to test various hypotheses on the channels through which the RER misalignment could affect economic growth in developing countries. The RER misalignment is estimated by the reduced-equation approach, using alternative price indices. Estimated indicators of the RER misalignment are found to be highly correlated to each other, especially between indices derived from the same method or price index.

The first empirical model examines the role of financial integration in determining the nexus between the RER misalignment and economic growth. The interaction between the RER misalignment and financial integration is investigated in a typical growth model. The panel-corrected standard error estimator is employed. It finds that the RER misalignment and economic growth relationship is statistically significant and that the growth-enhancing effect of undervaluation is strengthened by a lower degree of financial integration. This finding implies that a less financially integrated economy could benefited more from a competitive exchange rate than a highly financially integrated economy.

The second empirical model tests the hypothesis on the linkage between the RER misalignment and productivity. Total factor productivity (TFP) is estimated by two alternative methods, growth accounting and data envelopment analysis (DEA). It finds significant evidence to support that a depreciated RER could promote TFP growth. Moreover, the effect of the RER misalignment on TFP growth is found to be sizable.

ACKNOWLEDGEMENTS

I want to acknowledge my debt to my primary supervisor, Professor Sarath Delpachitra, for not only his enthusiastic guidance but also his understanding and support during the time I carried out my PhD research. This thesis is impossible without his encouragement. I am indebted him as a person who takes me under his wing, providing me with numerous opportunities to learn and develop as an economics researcher.

My sincere gratitude is reserved for Dr. Sigitas Karpavicius for his invaluable insights and suggestions. I was benefited a lot from useful discussions with him. I really appreciate his willingness to explain complicated and technical issues, and go through several drafts of my thesis. I remain amazed and motivated by his rigorous research attitude.

I am grateful to the Flinders Business School for giving me the opportunity to accomplish my research and for their financial support.

Finally, I wish to thank my parents and extended family. To them I dedicate this thesis.

STATEMENT OF ORIGINAL AUTHORSHIP

I certify that this thesis does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any university; and that to the best of my knowledge and belief it does not contain any material previously published or written by another person except where due reference is made in the text.

Signed:………………………………………………

Dai Pham Van

PUBLICATIONS ARISING FROM THE RESEARCH

Refereed journal papers

1. Dai, P. V., & Delpachitra, S., 2015, *"The RER misalignment and total factor productivity: An empirical analysis in East Asian economies",* Economic Papers: A Journal of Applied Economics and Policy (Forthcoming in Sep 2015)
2. Dai, P. V., & Delpachitra, S., 2014, *"Does real exchange rate appreciation boost capital accumulation? an intertemporal analysis",* Australian Economic Papers, Vol 53, 230-244 (1). http://dx.doi.org/10.1111/1467-8454.12031

Under review

1. Dai, P. V., & Delpachitra, S., 2015, *"Real exchange rate and economic growth in East Asian countries: The role of financial integration",* Journal of Development Areas.

LIST OF ABBREVIATIONS

AIC	Akaike Information Criterion
2SLS	Two-Stage least Squares
3SLS	Three-Stage Least Squares
APEC	Asia–Pacific Economic Cooperation
AR(1)	First-order serial correlation
ARDL	Autoregressive-Distributed Lag
ASEAN	Association of Southeast Asian Nations
ASEAN+1	ASEAN plus one
BEER	Behavior equilibrium real exchange rate
BIC	Schwarz' Bayesian Information Criterion
BRER	Biletaral real exchange rate
CPI	Consumer price index
DEA	Data envelopment analysis
DEER	Desired equilibrium change rate
DOLS	Dynamic least square
EAS	East Asia Summit
ECM	Error correction model
EMEAP	Executives' Meeting of East Asia–Pacific
ERER	Equilibrium real exchange rate
FEER	Fundamental Equilibrium Exchange Rate
G7	The Group of 7
GDP	Gross domestic product
GMM	generalised method of moment
GNP	Gross National Product
HQIC	Hannan-Quinn Information Criterion
ICOR	incremental capital-output ratio
IV	instrumental variable
NATREX	Natural equilibrium real exchange rate
NIEs	Newly industrialised economies
OECD	Organisation for Economic Co-operation and Development

OLS	Ordinary least squares
PCSE	Panel-corrected standard error
PMG	Pooled mean group
PPP	Purchasing power parity
PSTR	Panel smooth transition regression
REER	Real effective exchange rate
RER	Real exchange rate
TFP	Total factor productivity
US	United States of America
WPI	Wholesale price index

CHAPTER 1

INTRODUCTION

1.1 Background

Since the collapse of the Bretton Woods system of fixed exchange rates in the early 1970s, developing countries have been more active in exchange rate management. Over time, the fixed exchange rate regime was replaced by more frequent adjustment regimes. Regardless of the exchange rate regimes adopted, the majority of developing countries have attempted to acquire favourable exchange rates rather than leaving them fully affected by the market. In fact, this is one of the overriding concerns of policymakers due to the enormous influence of exchange rates on cross-border economic transactions, e.g. investment and trade.

Determining an appropriate value of an exchange rate appears not to be an easy task. There have been a number of exchange rate crises over recent decades, occurring in East Asia, Russia, Mexico and Brazil, of which exchange rate misalignment is believed to be a fundamental cause. After the Latin American financial crisis in the early 1980s, US government and international institutions based in Washington, namely the World Bank and International Monetary Fund, adopted the neoclassical viewpoints to form their economic policy descriptions aimed at improving economic growth in developing countries. Then widely named the Washington consensus, this mainstream viewpoint argued that developing countries should avoid both overvaluation and undervaluation but maintain equilibrium levels of exchange rates. A summary of this manifesto can be found in Williamson (1990):

"In the case of a developing country, the real exchange rate needs to be sufficiently competitive to promote a rate of export growth that will allow the economy to grow at the maximum rate permitted by its supply-side potential, while keeping the current account deficit to a size that can be financed on a

sustainable basis. The exchange rate should not be more competitive than that, because that would produce unnecessary inflationary pressures and also limit the resources available for domestic investment, and hence curb the growth of supply-side potential.”

Application of the Washington consensus led to disappointing results in the 1990s. For example, it is a popular belief that the poor performance of Latin American countries in the 1990s was partly due to the Washington consensus policies (Palma, 2003). Moreover, there was a sequence of financial crises during this period such as the tequila crisis in Mexico in 1995, the Asian financial crisis and the accompanying crisis in Russia in 1997, Brazil’s financial turmoil in 1997-1999, Ecuador’s crisis in early 2000 and the Argentine great depression in 1998-2000. By contrast, some countries rejected the neoclassical principles of the Washington consensus and tried to follow a pro-active policy in attaining highly competitive exchange rates rather than equilibrium rates. An interesting example is China’s currency, which has been allegedly manipulated to promote exports and economic growth during recent decades. China’s spectacular growth performance is observed to be accompanied by massive accumulation of foreign reserves.

This practice stimulates the mercantilist viewpoint on the exchange rate policy. There have been recently an increasing number of scholars bolstered by the success of export-led growth strategies in developing countries arguing for the mercantilist viewpoint (e.g. Bereau, Villavicencio, & Mignon, 2012; Hausmann, Pritchett, & Rodrik, 2005; Prasad, Rajan, & Subramanian, 2007; Rodrik, 2008). While both the mercantilist and Washington consensus viewpoints argue for the negative effect of overvaluation on economic growth, they hold differing views on the impact of undervaluation. The distinction is that mercantilists believe in the positive growth-effect of undervaluation and hence recommend developing countries’ governments to target undervalued exchange rates rather than equilibrium levels.

The debate between the two schools is not only theoretically important but also provides enormous practical value. On the theoretical side, the central issue is about the causality of the relationship between the real exchange rate (RER) misalignment and economic growth. The RER misalignment is not a policy instrument and thus it is not clear how a country could, if possible, attain a targeted level of RER misalignment and what cost it would pay to pursue such a strategy. Statistical correlation between the RER misalignment and economic growth could be misleading if the causality between them is multidirectional or unidirectional from economic growth to the RER misalignment.

On the practical side, if the mercantilist viewpoint is right, this would lead to fundamental change in designing monetary policy in developing countries. They could make use of their exchange rates as a development tool to maximise economic growth rather than solely seeking for equilibrium exchange rates to attain economic stability. Competition between developing countries to devalue their currencies against others, which have been known as the “currency war” symptom, could arise and this could lead to fundamental reform in international economic relations.

There have been a large number of studies empirically examining the existence of the RER misalignment and economic growth relationship, perhaps due to the academic and practical importance of this topic (see, for example, Bereau et al., 2012; Bhalla, 2007; Bleaney & Greenaway, 2001; Cottani, Cavallo, & Khan, 1990; Dollar, 1992; Gala, 2008; Hausmann et al., 2005; Nouira & Sekkat, 2012; Prasad et al., 2007; Razin & Collins, 1999; Razmi, Rapetti, & Skott, 2012; Rodrik, 2008; Schroder, 2013; Vieira & MacDonald, 2012) . Although the majority of studies report a statistically significant correlation between the RER misalignment and economic growth, there are some empirical issues preventing audiences from being persuaded by documented empirical evidence.

Firstly, since the RER misalignment is not directly observed it must be derived by some specific estimations. In fact, there is no overwhelming method to measure exchange rate misalignment, with particular concerns about measurement errors. The first set of measurement errors is related to estimation of the RER. As the RER can be defined internally or externally, there is no unique price index motivated by theory in calculating the RER. Besides the problems with price index, estimating the multilateral RER involves difficulties in determining a precise trading-weight scheme, e.g.

addressing the third-country problem and selecting a criterion such as exports, imports or total trade volume to be used for the weight scheme. Moreover, parallel good and exchange markets often exist in developing countries and complicate matters further.

Another set of measurement errors concerns estimating the equilibrium real exchange rate (ERER). Although identifying the ERER is a crucial step to derive an estimation of the RER misalignment, there is no highly effective method to estimate the ERER. The conventional purchasing power parity (PPP) hypothesis to determine the ERER is very often rejected by empirical studies. The general equilibrium approach to define the ERER provides a firm theoretical framework to define the ERER but it is implausible to simulate a general equilibrium economic system in the majority of developing countries due to the unavailability of statistical data and computational burden. In practice, most empirical studies apply the reduced-equation approach introduced by Edwards (1988) to estimate the ERER due to its simplicity and despite there being no solid theoretical foundation and consistent framework to select fundamental variables to be added in an ERER reduced-equation model. Perhaps for this reason, estimations of the ERER often substantially differ among empirical studies. Importantly, measurement errors in estimating the RER and ERER seem to influence the empirical result of the estimation of the RER misalignment and economic growth linkage. For example, in a recent study, Schroder (2013) addresses the heterogeneity issues in estimating the RER misalignment and comes to a finding opposed to the dominant evidence reported in the literature.

While most attention has been devoted to seeking empirical evidence of the exchange rate misalignment and economic growth nexus, the theoretical side of this problem is to a large extent ignored. The RER received little attention in neoclassical economics, which tends to consider the exchange rate as an endogenous variable. Neoclassical growth models such as those developed by R. Solow (1957) and Rostow (1960) feature closed-economies in which the RER has no importance. Lewis's theory on the reallocation process of labour from the rural area to the modern manufacturing sector (Lewis, 1954) was perhaps the first suggestion on role of the RER misalignment as a development tool. Nevertheless, there has been so far no thoroughly theoretical understanding of the channel through which the RER misalignment could influence economic growth.

Analyses on the consequence of the RER misalignment have been mostly carried out in the context of Keynesian economics (e.g. Gala, 2008; Porcile & Lima, 2010). This stream focuses mainly on the short-run effect of the RER misalignment under some critical assumptions of market imperfection. For example, Gala (2008) extended Lewis's theory by arguing that a depreciated RER causes lower real wages and makes firms more lucrative, and thereby promotes investment. Porcile and Lima (2010) relied on the balance of payments constraint growth model to demonstrate that a depreciated RER could stimulate economic growth by expanding exports.

Rodrik (2008) made a pioneer study on the long-run impact of the RER misalignment. He argued that undervaluation could cancel out the negative effect of government intervention and market failures on the tradables sector and thereby stimulate economic growth. Nevertheless, Rodrik (2008)'s static equilibrium model is criticised for being built on questionable assumptions that government intervention and market failures have a disproportionately negative effects on tradables. In general, the literature documents two main hypotheses on the positive growth effect of undervaluation (P. Montiel & Serven, 2008). The first argues for the effect of a depreciated RER on reallocating production resources from the non-tradables sector to the tradables sector. This could eventually improve an economy's productivity due to the "learning by doing" process. The second hypothesis focuses on the role of a depreciated RER in stimulating investment through a more profitable tradables sector. Nevertheless, the literature is still at the early stage of exploring the theoretical aspects of the RER misalignment and economic growth relationship (P. Montiel & Serven, 2008)

1.2 Research problem and methodology

Despite a strong desire in academic and policy-maker circles to explore the impact of the RER misalignment on economic growth, the literature has so far achieved very little consensus. It is essential to have more insights into the channels through which the RER misalignment influences economic growth. Such understanding could help determine that whether the positive growth effect of undervaluation exists as a general rule or is just a phenomenon emerging in specific circumstances.

This thesis provides a theoretical explanation of the investment channel on the effect of the RER misalignment on economic growth in a well-specified dynamic system. The theoretical model in this thesis follows the neoclassical setting thereby distinguishing it from previous studies (e.g. Gala, 2008; Porcile & Lima, 2010) which were developed in Keynesian frameworks. The model features the circumstances of developing countries by focusing on the impact of the RER misalignment along the growth process. Notably, because conventional general equilibrium models tend to focus on examining the steady state properties of an economy and thus are more appropriate to capture the behaviour of developed economies, the dynamic analysis approach in this study seems to be superiour in examining behaviours of developing countries that are not in the vicinity of the steady state.

On the empirical side, attention has been so far focused on the correlation between the RER misalignment and economic growth rather than the transmission mechanism of this relationship. To fill this gap in the literature, this thesis examines the role of financial integration in determining the relationship between the RER misalignment and economic growth. It is argued that the role of undervaluation in promoting economic growth is more substantial in less financially integrated economies. Because countries with higher degrees of financial integration tend to be less subjected to balance of payment constraints, the effect of devaluation in stimulating investment could be marginal in those countries. This hypothesis means that the impact of undervaluation would be not the same across countries and would be subject to their degrees of financial integration.

Finally, this thesis empirically investigates the impact of the RER misalignment on total factor productivity (TFP). Although productivity is widely believed to be one of the main channels through which the RER misalignment influences economic growth, there has been little attempt to empirically examine the correlation between productivity and the RER misalignment. This thesis supplements the existing body of literature by providing a comprehensive study, which employs a number of estimations of TFP and the RER misalignment in order to avoid misleading empirical results caused by measurement errors.

Whereas the majority of the empirical literature investigates the impact of the RER misalignment using heterogeneous samples consisting of a large number of countries, this thesis makes use of a relatively small and homogenous sample of developing East Asian economies. Nine economies are included in the sample, namely: Hong Kong, South Korea, Singapore, Malaysia, Indonesia, Philippines, Thailand, China and Vietnam. The East Asian economic region is of special interest for three reasons. First, the regional economies are characterised by high economic performance and the success of export-led growth strategies. The role of the RER misalignment should be extraordinarily important in these countries because of their high degrees of openness and large shares of manufacturing and tradable goods sectors in GDP. Second, since the role of the RER misalignment tends to be different among countries, a more homogeneous country panel could improve the robustness of empirical results. Although the well-known generalised method of moment (GMM) estimator, which is compatible with a panel of large cross-section and small time-series observations, can efficiently address the endogeneity issue, its efficiency largely depends on the quality of instruments. For this reason, this thesis could well complement the existing literature by its employment of a long time dimension panel and use of appropriate regression techniques.

1.3 The structure of the thesis

The remainder of this thesis is organised as follows:

Chapter 2 reviews theoretical and empirical issues related to estimating the RER misalignment. It starts with a summary of the internal and external approaches to define the RER. It discusses the appropriateness of price indices in measuring the RER, and empirical problems in determining a trading-weight scheme to estimate the multilateral RER. In the next part, the concept and measurement of the ERER are investigated. The chapter highlights the failure of conventional PPP theory to empirical scrutiny and then summarises the development of alternative approaches to estimate the ERER, namely the partial equilibrium approach, the general equilibrium approach and the reduced-equation approach.

Chapter 3 reviews the literature on the relationship between the RER misalignment and economic growth. The first part of this chapter examines theoretical works while the second part focuses on the empirical literature. Special interest is paid to empirical studies carried out in East Asian countries. Notably, besides the correlation between the RER misalignment and economic growth, this chapter also pays attention to empirical works examining the effect of the RER misalignment on productivity and investment.

Chapter 4 and Chapter 5 examine the influence of a RER movement on investment behaviour of a theoretical economy.

In particular, chapter 4 presents the setting of a two-sector economy model in which the interest is on the optimisation behaviour of a representative firm in the tradables sector. The intertemporal optimisation framework is used to analyse the dynamic economic system. It then investigates the response of a representative firm to an impulse from a one-time, permanent, unanticipated depreciation in the RER.

Chapter 5 calibrates the theoretical model established in Chapter 4 in order to gain a sense of the magnitude of the impact of a RER movement on investment. Two separate calibrations are carried out under two different assumptions about the production function of the tradables sector. The constant returns to scale form of the tradables production function is first considered and then a more general form of a strictly concave function is used.

Chapter 6 comprises three parts. The first part analyses the main social-economic characteristics of East Asian economies. The second part presents the empirical algorithm to estimate the RER misalignment indices for the sampled East Asian economies. Based on the results of the RER misalignment estimation algorithm described in the second part, the third part discusses the exchange rate misalignment problem in the sampled economies.

Chapter 7 makes use of the RER misalignment indices estimated in Chapter 6 to examine empirically the relationship between the RER misalignment, financial integration and economic growth in the panel of East Asian economies. This chapter focuses on the impact of the interaction terms between the RER misalignment and financial integration on economic growth rather than the direct correlation between the RER misalignment and economic growth.

Chapter 8 empirically examines the productivity channel through which the RER misalignment might affect economic growth. This chapter takes into account two measures of productivity estimated by the growth accounting and the non-parametric frontier analysis method. The productivity indices are then regressed on the RER misalignment indices estimated in Chapter 6.

Finally, a summary of key findings is presented in Chapter 9. This chapter emphasises the contribution of this thesis to the existing literature as well as its practical implications. Moreover, it states the limitations of this thesis and makes suggestions for further research.

CHAPTER 2

MEASUREMENT OF THE REAL EXCHANGE RATE MISALIGNMENT

2.1 Introduction

Measurement of the RER misalignment is a major difficulty in empirical studies on the consequences of the RER misalignment. There are two problem sets in measuring the RER misalignment, which are concerned with the concepts and measurements of the RER and the ERER. Estimating the RER misalignment starts with measuring the RER. Although the definition of the RER is straightforward, there is much complication in measuring the RER, especially in developing countries. In the second problem set, the ERER seems to be confusing at both the theoretical and empirical levels. Since the RER misalignment is derived from estimated values of RER, the ERER, it is not surprising that there is an ongoing debate and no consensus on a framework for measuring the RER misalignment.

The role of this chapter is twofold. First, it attempts to review the alternative definitions of the RER and to discuss the main empirical issues in estimating the RER. Second, it summarises the evolution of the concept of the ERER and investigates different approaches to estimate the ERER. The dominant content of this chapter is devoted to reviewing the advantages and disadvantages of different ERER estimation frameworks that appear to be of particular concern in empirical studies.

The remainder of this chapter is structured as follows. In Section 2.2, the concept and measurement of the RER are reviewed, with a particular focus on the ambiguity in selecting a price index. Section 2.3 analyses approaches to define and estimate the ERER, namely the PPP-based approach, the partial equilibrium approach, the general equilibrium approach and the reduced-equation approach. Section 2.4 summarises key points of this chapter.

2.2 The real exchange rate: Concept and measurement

There is much ambiguity in the concepts and measurements of the RER and the ERER despite their appearance in the centre of economic and policy discussions for more than the last two decades. The complication is that each analytical framework used in a particular circumstance could lead to a different conceptual definition of the RER (Hinkle & Montiel, 1999). There are conceptually two main approaches to define the RER. The first one relies on the PPP theory to define the RER externally as the adjustment of the nominal exchange rate from the disproportionate changes in domestic and foreign price levels. The second approach makes use of a class of open two-sector economy models (e.g. Dornbusch, 1975) in which the RER can be internally identified as the relative price of non-tradables to tradables, or sometimes as the relative price of non-tradables to imports and exports[1]. Notably, the internal approach is more advantageous than the external approach in theoretical analysis, but it is less applicable in empirical studies because the statistical data on the price levels of tradables and non-tradables are often not available.

In the external approach, the RER can be measured bilaterally or multilaterally. In the form of a bilateral rate, the RER of a home country i to a foreign country j can be expressed as:

$$BRER_{ij} = \frac{E_{ij}p_j}{p_i} \tag{2.1}$$

Where $BRER_{ij}$ is the bilateral RER between countries i and j, measured in country i's domestic currency term; E_{ij} is the nominal bilateral exchange rate

[1] The “external real exchange rate” and “internal real exchange rate” terminologies are respectively adopted by De Gregorio and Wolf (1994) and Hinkle and Montiel (1999).

in country i's domestic currency term; p_i and p_j are respectively countries i and j's price indices.

The multilateral RER is also named as the real effective exchange rate (REER). Put simply, it is a pooled rate derived from a bundle of a home country's bilateral RER rates. The REER concerns the trade relationships between a home country and its trading partners. The REER of a home country i can be computed by the following formulae:

$$REER_i = \prod_{j=1}^{m} [E_{ij} p_j]^{w_j} \frac{1}{p_i} \tag{2.2}$$

$$\sum_{j=1}^{m} w_j = 1 \tag{2.3}$$

where m is the number of the home country i's trading partners in the bundle; E_{ij} is the nominal bilateral exchange rate of the home country i to a trading partner j , and is measured in country i's domestic currency term; p_i and p_j are respectively countries i and j's price indices; and w_j is the trade weight of country j in the bundle of country i' trading partners.

Notably, there are some empirical issues in measuring the BRER and REER that make estimated results ambiguous. The most noticeable problem is to select an appropriate price index to use in Equations (2.1) and (2.2). In fact, there are several approaches to define the RER and each of them motivates a different price index. In respect to the conventional PPP approach, the price index should concern both tradables and non-tradables to represent a standardised basket of goods. Thus, the consumer price index (CPI) is most favourably used in the PPP-based approach (Genberg, 1978). However, in the view of the standard Mundell – Fleming model, it is assumed that each country produces a single product that is used for both domestic consumption and exporting. Therefore, in order to measure the competitiveness of a country's domestic production, the price index must represent the relative price of domestically produced goods to imports. Thus, the GDP deflator index, which excludes imports from the goods basket, is recommended. Besides, GDP deflator has another advantage in that it is less sensitive to price control policies (Officer, 1976, 1982) than CPI. Another price index that is popularly used to calculate RER is the wholesale price index (WPI). Since WPI involves mostly the tradable subset of goods, it has advocates who argue that the PPP theory and the rule of one price is applicable only with tradable goods and the RER measures the competitiveness of the tradable sector. Notably, WPI has, nonetheless, its own drawbacks such as the double counting problem (Artus & Knight, 1984). In some studies in developed countries, labour cost index could also be in use due to the fact that it is more stable than other price indexes and better reflects the competitiveness of an economy (Artus, 1978; Artus & Knight, 1984; Officer, 1982; Zanello & Desruelle, 1997). Even so, the reason that the labour cost index-based REER is not popular in empirical studies, especially in developing countries, is the unavailability of labour cost statistics (Hinkle & Montiel, 1999).

The impact of a price index in calculating the RER was demonstrated by Edwards (1989) who compared results of different RER estimation frameworks. He estimated the REER and BRER for 36 countries by both internal and external approaches. The empirical result demonstrates that the internal and external REER measurements tend to move together whereas the internal and external bilateral RER measurements move divergently or even oppositely.

The second issue in estimating the RER concerns the choice of an appropriate nominal exchange rate. This problem emerges especially in developing countries where a parallel exchange rate may exist beside the official exchange rate. Because the effect of the parallel exchange rate on capital and trade transactions changes over time rather than being stable, using the official exchange rate to estimate the RER could be misleading. According to Jorgensen and Paldam (1987), it is likely that the official exchange rate is overvalued while the parallel rate is undervalued. It is, therefore, recommended to use a weighted average of the official and parallel exchange rates. The weighting should reflect the relative size of the parallel market to the official market. Jorgensen and Paldam (1987) argued that the weighted rate is more stable and better represents the price of a country's domestic currency than the official or parallel rate. However, it is highly unlikely that the scale of parallel market can be measured accurately and thereby the weighting tends to be subjective instead of relying on statistical background (Hinkle & Montiel, 1999).

In addition, there are some particular empirical difficulties in estimating the REER. Firstly, the simplest and most popular method to weight a trading partner's currency in a home country's currency bundle is to use the size of the trading relationship between them. However, it does matter whether import or export volume could be used, especially when the import and export patterns among countries are substantially different. In fact, this depends on a particular analytical purpose (Hinkle & Montiel, 1999). For example, since a RER movement has divergent impacts on the home country's import and export industries, whether an import- or export-weighting scheme is more appropriate depends on the nature of the industries examined. To this end, even more disaggregated data such as trade volume of a certain product or a cluster of products could be used for particular analyses.

Nevertheless, a trade-weighting scheme is difficult to be determined accurately due to the third-country competing issue. This issue arises when a home country's exports competes against a third country's products in its trading partner's market. Obviously, a third country's currency devaluation or revaluation influences the competitiveness of the home country's exports. However, since there is no direct trading relationship between the home country and the third country, the third country does not appear in the bundle of the home country's trading partners and hence fluctuation of the value of the third country's currency does not affect the home country's REER. A similar problem exists when the home country's importing partners can sell less or more of their exports to a third-country as a replacement for the home country's market. Unfortunately, fully incorporating the third-country's trading linkages into the weighting scheme is a cumbersome task and for that reason, there is no plausible method to address the third-country issue in empirical studies.

Secondly, the issues of unrecorded trade in developing countries could seriously distort the weighting indices. The official statistic may not precisely reflect the trade volume between the home country and its trading partners, especially for countries who share a border. Similar to the issue of the parallel market exchange rate, it is incapable of measuring precisely the parallel trade market scale. For that reason, Hinkle and Montiel (1999) stated that due to the deficiency of statistical data, the choice of an appropriate weighting scheme could be considered as much an art as a science.

2.3 The equilibrium real exchange rate: Concept and estimation

2.3.1 Concept of the equilibrium real exchange rate

The concept of the equilibrium real exchange rate (ERER) has been long examined by theorists. For instance, dating back to the early 20th century, the Swedish economist Gustav Cassel developed the PPP theory which modeled the movement of a nominal exchange rate as to offset the differences in price levels between countries (i.e Cassel, 1922). The PPP–based approach had been, nevertheless, criticised as being unable to bring a precise interpretation of the ERER (Stein, 1994). In a later study, Nurkse (1945) defined the ERER as a level at which the balance of payment is in equilibrium without trade restriction measures and the economy is at a full employment state. Nurkse (1945)'s notion on the ERER was then advanced by Williamson (1983, 1994) who argued that the conventional external equilibrium condition for the ERER that capital flows are neutralised by current flows and there is no change in international reverses, is not sufficient. Williamson (1983) proposed to define the ERER as a level that generates a current account surplus or deficit equal the underlying capital account excluded from short-term capital flows[2]. He illustrated an example that showed a very large current account deficit, financed by a massive capital account surplus, can be unsustainable in real life even though it is defined as equilibrium according to the traditional approach. Consequently, the ERER was argued to be consistent with a

[2] Williamson (1983) named his method the Fundamental Equilibrium Exchange Rate (FEER), which has been widely used as an alternative to the PPP approach to estimate the ERER.

targeted level of current account balance determined by long-term position of the capital flows.

In a recent study, Driver and Westaway (2005) argued that the concept of ERER is not straightforward because it is subjected to the time horizon over which the RER obtains its equilibrium state. They defined the ERER by characterising the RER as a function of explanatory variables, which can be expressed in the form of a reduced equation:

$$RER_t = \beta Z_t + \theta T_t + \varepsilon_t \tag{2.4}$$

where Z is a vector of fundamentals; T is a vector of transitory factors; and ε_t is a stochastic disturbance caused by random factors. Driver and Westaway (2005) classified the equilibrium concept of the RER by different time horizons. The short-term equilibrium was defined as the state where the fundamentals and transitory determinants are at their current settings and there is no stochastic disturbance:

$$RER_t^{Short-term} = \beta Z_t + \theta T_t \tag{2.5}$$

In essence, the short-term equilibrium is the actual RER abstracted from the impacts of unexpected shocks (Equation (2.5)). This concept of short-term ERER is indeed closely related to the current equilibrium exchange rate framework developed by Williamson (1983) who defined the ERER as the underlying exchange rate if the market has all the information on the shocks and responses rationally. Notably, the short-term ERER is associated with the actual values rather than the equilibrium value of fundamentals because it must be consistent with the short-term state of the whole economy where disequilibrium exists. For that reason, an estimation of short-term ERER often requires using the actual output instead of the potential output.

The medium-term equilibrium RER was defined by Driver and Westaway (2005) as the level at which the economy attains both internal and external balances. The internal balance is characterised by two features: zero output gap and non-accelerating inflation. The external balance condition requires the current account to be at a sustainable level in the sense that it is consistent with the adjustment process toward the stock equilibrium of the balance of payments. More specifically, the medium-term equilibrium could be considered as an underlying RER attained by real terms of variables, without price rigidities and cyclical factors. Different from the short-term ERER, the medium-term ERER are not estimated by using actual values but by using trend values of fundamental factors (Equation (2.6)).

$$RER_t^{Medium-term} = \beta Z_t^{trend} \quad (2.6)$$

Finally, Driver and Westaway (2005) defined the long-term equilibrium RER as the steady state value of the RER. The feature distinguishing the long-term equilibrium from the medium-term equilibrium is that the condition of the medium-term internal and external balances allows assets stocks, e.g. foreign debt, capital stock and domestic interest rate, to adjust over time while the condition of long-term internal and external balances requires asset stock to be constant[3] (Equation (2.7)).

$$RER_t^{Long-term} = \beta Z_t^{Steady\ state} \quad (2.7)$$

2.3.2 Empirical estimation of the ERER

Empirical estimation of the ERER has important implications not only in academic debates but also in policy-making (Driver & Westaway, 2005). In particular, determining the relative position of an exchange rate to its equilibrium level can provide some clues on the trend of exchange rate movements. However, the usefulness of empirical ERER estimation has been questioned by scholars who mostly belong to two schools (Isard & Faruqee, 1998). In the first school it is argued that there is no substantial difference between the actual RER and the ERER because the actual RER is often conditioned by the fundamental factors and hence moves closely with the ERER. The second school is skeptical of the ability to estimate accurately the

[3] Driver and Westaway (2005) based their definition of long-term equilibrium on the Milgate (1998)' analysis that long-term equilibrium of the economy is the point from which there is no endogenous tendency to change.

ERER while accepting that the actual RER and the ERER can significantly diverge.

2.3.2.1 The PPP theory approach

In essence, the PPP theory claims that movement of the actual RER is merely the cyclical fluctuation around a constant level of the ERER. This hypothesis can be expressed in terms of the following formulas:

$$\ln(NER) = \alpha + \beta_1 \ln \mathrm{P} - \beta_2 \ln \mathrm{P}^* + \varepsilon \qquad (2.8)$$

$$\beta_1 = \beta_2 = 1 \qquad (2.9)$$

where P and P^* are respectively the domestic and foreign price levels; α is a constant; and ε is the stationary random disturbance. According to the PPP theory, the nominal exchange rate adjusts to offset price movements. The ERER equals α and is unchanged over time. The actual RER is essentially transitory departures from the ERER.

Unfortunately, although being a straightforward approach to identify the ERER, the PPP theory receives little empirical support. Sarno and Taylor (2002, pp. 58-73) made an extensive review of empirical studies on the PPP theory and categorised it into six subgroups. The first group is early studies on PPP involving estimating the Equation (2.8) and testing the PPP hypothesis: $\beta_1 = \beta_2 = 1$. These studies contain severe problems of endogeneity and spurious regression, and they tend to reject the PPP hypothesis. The second group relies upon the unit root testing procedure to examine the stationarity of the RER. Most of these studies fail to reject the unit root hypothesis of the RER and hence advocate permanent deviation of the RER from PPP. The third group is cointegration studies, which investigate the existent of a stable long-run relationship between the nominal exchange rate, and domestic and foreign price levels. The cointegration hypothesis is often rejected and coefficients of the co-integrating vectors, if they exist, often largely diverge from the theoretically expected values. The fourth group of studies argues that the mean-reversion process of the RER happens during extremely long periods. They try to find evidence supporting the PPP theory by employing more than

70-year long-span samples, e.g. Frankel (1986), Edison and Klovland (1987), Glen (1992), Cheung and Lai (1993) and Lothian and Taylor (1996). The fifth group uses panel data to test the random walk hypothesis of the RER. This approach is less informative due to the nature of panel data unit root tests. The rejection of the null hypothesis of a panel data unit root test should precisely imply that there is at least one stationary series in the panel rather than that all series in the panel are stationary. The final group conjectures that the deviations from PPP may be mean-reverting by a nonlinear trajectory. They assert that the deviation of the actual RER from the ERER may last for a long period but does not follow a random walk pattern. Some supporting empirical evidence is reported in the studies of Michael, Nobay, and Peel (1997) and Taylor, Peel, and Sarno (2001).

As empirical studies fail to verify the conventional PPP hypothesis, it is often explained that the ERER might be driven by fundamental factors that are not stationary over time. A recent trend in the literature is to determine these fundamental factors and incorporate them into the ERER equations for empirical purposes. The Balassa effect, which was originally discussed in the pioneer article by Balassa (1964), is perhaps the most widely acknowledged factor in the literature as a force driving the divergence of the RER from PPP[4]. In essence, Balassa (1964) claimed that the productivity in the tradables sector grows faster than that of the non-tradables sector. Assuming internal labour mobility, productivity improvement in the tradables sector raises the wage level

[4] Literature often names this Balassa effect as the Balassa-Samuelson effect as a tribute to Balassa (1964) and Samuelson (1964). This effect is also named differently as the Harrod–Balassa–Samuelson, Ricardo–Viner–Harrod–Balassa–Samuelson–Penn–Bhagwati, Ricardo-Balassa–Samuelson, or Ricardo-Balassa effect. However, according to Harberger (2003), Samuelson (1964) does not directly address the distinction between tradables and non-tradables sectors. Harberger (2003) stated that *"I was surprised in my reading of the Samuelson paper, because its content and focus were so different from what I had been led to expect by the frequent references in the literature to the Balassa-Samuelson effect ..So far as I can see, Samuelson makes no such direct assertion anywhere in the paper…I find nothing in his comments that I would interpret as predicting a secular trend toward currency appreciation as a country's per capita income grows through time, or a tendency for the cost of baskets of goods to be cheaper in countries with higher productivity."*

in the whole economy. This increases the price of non-tradables relative to tradables since the price of tradables is equal across countries due to the law of one price and therefore, even if there is a perfect law of one price in the tradables sector, PPP theory does not work out for whole economy. Increase in the relative price of non-tradables makes the whole economy's price level rise disproportionately to the nominal exchange rate level. Balassa (1964) considered per capita income as a representative for productivity advance and thereby predicted that the ERER could be formed as an increasing function of per capita income.

While the Balassa effect provides a supply-side explanation for non-constant ERERs, the literature also emphasises the role of demand-side fundamental factors. Baumol and Bowen (1966) argued that since the income-elasticisty of services and other non-tradables are higher than tradables, productivity growth could result in higher demand for non-tradables compared to tradables. For this reason, the relative price of non-tradables to tradables tends to rise over time. In a well-known study, De Gregorio, Giovannini, and Wolf (1994) identified a demand shift toward non-tradables as a primary cause of the inflation disparity across tradables and non-tradables sectors.

De Gregorio and Wolf (1994) attempted to merge those two literature strands by incorporating both supply-side and demand-side fundamental factors in an ERER model. They employed a two-sector economy model featured by capital immobility to reveal that the terms of trade fluctuation and the differential productivity growth across sectors are fundamental factors affecting the ERER. Examining the sample consisting of 25 OECD countries, they found empirical evidence supporting the effect of the differential productivity growth across sectors, the terms of trade, and government spending on the ERER. Similarly, MacDonald (1998) examined the determinants of the ERER using a sample consisting of the US dollar, German mark, and Japanese yen over the floating exchange rate period, from 1975 to 1993. He applied the cointegration test developed by Johansen (1991) to inspect the relationship between the REER and fundamental factors, and found that productivity, the terms of trade, fiscal balances, net foreign assets and the real interest rate are determinants of the ERER.

P. J. Montiel (1999b) analysed determinants of the ERER in the context of a general equilibrium model designed to feature a representative developing country. In this setting, the long-run ERER is determined by permanent values of policy and exogenous variables, and the steady-state level of the predetermined variables. He showed that there were four groups of variables affecting the long-run ERER. The first group is domestic supply-side factors, e.g. the Balassa effect. The second group consists of factors concerning to the fiscal policy, e.g. the tradables and non-tradables composition of government spending. The third group is international economic factors such as the terms of trade, external transfers, foreign countries' inflation, and the world real interest rate. The final group is factors involving commercial policies, e.g. export subsidies and import tariffs.

2.3.3 The partial-equilibrium approach

The partial-equilibrium approach is a popular framework that makes use of the trade elasticities to estimate the ERER. Simplicity is an obvious advantage of the partial-equilibrium approach in empirical studies. However, results of the partial-equilibrium approach is also criticised as imprecise and unreliable (Isard & Faruqee, 1998). Wren-Lewis and Driver (1998) pointed out two disadvantages of the partial-equilibrium approach. First, the potential output and structural capital flow are estimated independently while they are very likely to be interdependent. Second, the partial-equilibrium approach rules out the feedback effects of the RER on the rest of the model. For example, the RER probably has an effect on the potential output or capital account. They showed three channels through which the RER could influence the potential output. The RER can change the real income and hence affect labour supply. In addition, the RER affects the natural unemployment rate as well. Finally, it could change the cost of capital and thereby promote or discourage the capital accumulation process. Notably, since the income and price elasticities of imports and exports are difficult to precisely estimate, fitted value of a trade equation tends to be unstable out of the sample while containing serious errors within the sample.

Bayoumi, Clark, Symansky, and Taylor (1994) examined the issues concerning calculating a “desired equilibrium change rate” (DEER) under a certain medium-term policy target, e.g. a 1% current account surplus. Based on the partial equilibrium approach, they employed a comparative static analysis to estimate the desired DEER. Using the income and price elasticities of imports and exports provided by MULTIMOD MARK II (Masson, Symansky, & Meredith, 1990)[5], a trade equation was established for industrial G7 countries. They used estimated potential outputs of domestic and foreign economies to determine the output level at which an economy could obtain the internal balance. The long-run trade balance was computed by using MULTIMOD MARK II income elasticities and estimated internal balance levels of domestic and foreign outputs. The DEER is the level that eliminates the gap between the estimated long-run trade balance and the desired trade balance generating a targeted current account surplus.

Rather than using an ad hoc method to derive a sustainable level of the current account balance as Bayoumi et al. (1994), Isard and Faruqee (1998) developed an alternative partial equilibrium framework. They relied on a macroeconomic balance approach that links the surplus of domestic saving (S) over domestic investment (I) with the current account position (CUR):

$$CUR = S - I \tag{2.10}$$

Isard and Faruqee (1998) suggested a three–step framework to determine the ERER. In the first step, a trade equation is estimated to determine the underlying current account position that emerges at the prevailing exchange rate when all countries obtain their internal balance. Similar to Bayoumi et al. (1994), trade elasticities are extracted from MULTIMOD MARK II. They assumed that the influence of exchange rate movement on current account balance has a three-year pattern that there were 60 percent of total effect occurring in the first year, other 25 percent occurring in the next year, and the

[5] MULTIMOD MARK is a dynamic general equilibrium macro model for industrial countries, including a number of variables. It focuses on the transmission of economic shocks as well as consequences of economic policies in short and medium terms.

last 15 percent in the last year. Therefore, the current account equation has the following form:

$$
\begin{aligned}
(CA/Y)_{underlying} \\
&= (CA/Y) \\
&- [(M/Y)\beta_m + (X/Y)\beta_x][(RCUR - R) \\
&+ 0.4(R - R_{-1}) + 0.15(R_{-1} - R_{-2})] \\
&+ (M/Y)(RCUR - R) \\
&+ (M/Y)(RCUR - R) + (M/Y)\varphi_m YGAP \\
&+ (M/Y)\varphi_x YGAPF \qquad (2.11)
\end{aligned}
$$

where CA is the current account balance; Y, M and X are domestic output, imports and exports, respectively; $YGAP$ and $YGAPF$ are the logarithms of the ratios of the actual outputs to estimated potential outputs in the domestic and foreign economies, respectively; R, R_{-1} and R_{-2} are the logarithms of the REER at the current period, and one and two year lagged periods, respectively; $RCUR$ is the three-year average of the exchange rate; β_m and β_x are respectively the price elasticities of imports and exports provided by MULTIMOD MARK II; and φ_m and φ_x are respectively the income elasticities of imports and exports and assigned to be 1.5[6].

The second step in Isard and Faruqee (1998)'s framework is to estimate the equilibrium position of the domestic saving–investment balance conditioned on the internal balance position. A saving–investment equation was specified by using a bundle of medium-term explanatory variables, namely economic development proxied by per capita income; demographic structure proxied by the dependency ratio[7]; fiscal position captured in the form of the government budget surplus to GDP ratio; output gap measured by the difference between actual and potential GDP; and the world interest rate. The saving-investment balance was measured as the ratio of the current account to GDP or the ratio

[6] This ad hoc adjustment is based on a well-known survey (Goldstein & Khan, 1985) which pointed out that the range of the income elasticity of trade tend to lie from 1 to 2. Isard and Faruqee (1998) used 1.5 since it is the midpoint of the range.

[7] Dependence ratio is measured as the number of people aged younger than 20 or older than 64 over the number of people aged 20 to 64.

of change in the net foreign assets to GDP. The fitted value of the medium-term saving-investment balance was derived by setting output gaps at zero, per capita income at the level corresponding with potential output, and structural budget position at its trend value.

The final step is to estimate ERER by equilibrating the current account position and the medium-term saving-investment balance.

$$(CA/Y)_{underlying} - (CA/Y)_{equilibirum} = \theta(R_{equilibirum} - RCUR) \quad (2.12)$$

$$R_{equilibirum} = \frac{(CA/Y)_{underlying} - (CA/Y)_{equilibirum}}{\theta} + RCUR \quad (2.13)$$

where:

$$\theta = (M/Y) - [(M/Y)\beta_m + (X/Y)\beta_x] \quad (2.14)$$

It is worth noting that Isard and Faruqee (1998)'s framework has an advantage that it allows a wide range of fundamental factors involving in determining the ERER. It takes into consideration not only fundamental factors affecting the current account balance but also factors driving the capital account balance, e.g. the dependency ratio, the structural fiscal balance, and the world real interest rate. More importantly, unlike Bayoumi et al. (1994)'s method, it is carried out without normative content since the sustainable values of the fundamental factors is used instead of subjective values as Bayoumi et al. (1994) (Hinkle & Montiel, 1999).

Wren-Lewis and Driver (1998) applied the trade equation approach to estimate the ERER in G7 countries for two years, 1995 and 2000. Similar to Bayoumi et al. (1994) and Isard and Faruqee (1998), Wren-Lewis and Driver (1998) established a trade equation conditional on the prevailing RER and then determined the equilibrium trade balance level. A trade equation was formed in which the ratio of trade balance to GDP was a function of domestic and world outputs, the RER, and real commodity prices. Income and price elasticities of trade were derived from coefficients of an error correction model of the trade equation. To determine the equilibrium level of trade balance, Wren-Lewis and Driver (1998) relied on Williamson and Mahar (1998)'s analysis on the saving-investment balance target. In their study, Williamson and Mahar (1998) followed the government behaviour model advanced by Edwards (1995b) and private saving behaviour model developed Masson, Bayoumi, and Samiei (1998)[8]. The aggregate saving rate was derived from private and government saving rates which were estimated by projected values of their determinants. The investment rate was estimated using a subjectively adjusted incremental capital-output ratio (ICOR) and a forecast of the economic growth rate.

2.3.4 General equilibrium approach

In contrast to the partial equilibrium approach in which the ERER is determined as to achieve the current account equilibrium, the general equilibrium approach argues that an economy's current account equilibrium cannot be ensured without considering the economy as a whole. This approach often employs a general equilibrium economic model to guarantee that both internal and external balances are attained.

Williamson (1994) developed a pioneer general equilibrium framework to estimate the ERER, which was named the fundamental equilibrium exchange rate (FEER). In this approach, the ERER was considered as being identified by fundamental factors. He proposed a three-step framework to determine a

[8] In an empirical research, Edwards (1995b) found out that a 1 percent increase in the growth rate of real per capita income causes an increase of 0.63% GDP in the government saving, and a 1 percent increase in the current account deficit reduces the government saving by 0.53% GDP. Masson et al. (1998) found that a 1 percent increase in the real per capita income growth rate causes private saving increase by 0.16% GDP, a 1 percent increase in current account deficit reduces the private saving by 0.47% GDP, a 1 percent increase in the dependent ratio reduces the private saving by 0.18% GDP, and a 1 percent increase in government saving reduces the private saving by 0.66% GDP. In addition, the relationship between per capita income and private saving was shown to follow a quadratic form. The correlation between per capita income and private saving would be positive when per capital income is low. However, when per capita income passes over the level equivalent to 50% of the US per capita income, an increase in the per capita income would reduce private saving.

targeted level of the current account balance, including (i) comparing past current account imbalance with the domestic saving and investment gap; (ii) establishing a targeted level equal the past current account imbalance plus the amount of irrational imbalances; and (iii) modifying the targeted level to be internationally consistent. In order to estimate the domestic saving and investment gap, the investment need was estimated by applying the debt-cycle theory that hypothesises an inverse relationship between a country's investment rate and the relative scale of its capital stock to complementary production factors, e.g. labour. The domestic saving supply was measured based on the life–cycle personal finance model, which explains a country's domestic saving rate by its demographic factors. The next step involves selecting subjectively an inflation rate which was considered as desirable to sustain internal balances. After deriving the parameters of the desirable inflation rate and the targeted level of the current account balance, a FEER can be estimated by simulating a macroeconomic equation system with three constrains on the potential output level, the desirable inflation rate and the targeted level of current account[9].

In an alternative approach, Bayoumi et al. (1994) defined the general equilibrium ERER as a desirable level of RER rather than allowing it to be determined by fundamental factors as Williamson (1994). Bayoumi et al. (1994) named the ERER estimated by their general equilibrium frameworks as the desirable equilibrium change rate (DEER). A two-step procedure was applied to estimate the DEER. Firstly, they investigated the interaction between current account and foreign indebtedness in order to explore the hysteresis effect of the adjustment path on the DEER that was often ignored in conventional comparative static analyses. Interestingly, it was shown that the departure of the actual RER from the ERER could affect the equilibrium of debt service obligation and then change the ERER. In the second step, a full–MULTIMOD model was simulated to derive the DEER under different

[9] Bayoumi et al. (1994) applied six alternative macroeconomic models to estimate FEER, including the extend adjustment with growth model (Cline, 1989); the global econometric model (NIESR, 1990); interlink model (Richardson, 1988, 1990); intermod model (Meredith, 1989); Mimosa model (MIMOSA Modelling Group, 1990); and The McKibbin - Sachs model (McKibbin & Sachs, 1989).

scenarios, e.g. to obtain a normative 1% GDP level of current account surplus or to offset shocks in currency preferences and government spending. Bayoumi et al. (1994) compared the estimated DEER derived from two alternative partial and general equilibrium approaches, and concluded that results of the two methods are fairly similar. However, Bayoumi et al. (1994) conceded that both of the methods were at the preliminary stages and contained shortcomings. For example, these methods were subjected to the assumption about the desired condition of the external balance, which might not be an economy's actual equilibrium state.

Notably, both frameworks developed by Williamson (1994) and Bayoumi et al. (1994) require normative adjustments and that poses empirical difficulties. Stein (1994) developed an alternative general equilibrium framework that can avoid the arbitrariness of selecting normative parameters. Similar to Williamson (1994) and Bayoumi et al. (1994), Stein (1994) defined the ERER in the medium-term context. He named an ERER estimated by his framework as the natural equilibrium real exchange rate (NATREX). The NATREX was determined so as to facilitate the internal and external equilibriums characterised respectively by the natural unemployment and the equilibrium balance of payments. The equilibrium balance of payments was excluded from speculative and cyclical factors. The NATREX can then be estimated by the Equation (2.15):

$$R_t = \{R_t - R(K_t, D_t, Z_t)\} + \{R(K_t, D_t, Z_t) - R(Z_t)\} + R(Z_t) \tag{2.15}$$

where R, K, D and Z are respectively the actual RER, capital stock, external debt and exogenous shocks of fundamentals such as productivity improvement and social thrift. The difference between the actual RER and the long-run RER is decomposed into the divergence between the actual RER and NATREX caused by speculative and cyclical factors, and the gap between NATREX and its steady state.

Based on an intertemporal optimisation analysis of a structural general equilibrium system [10], Stein (1994) established a reduced form equation as below.

$$R_t = F(R_{t-1}, Z_{t-1}, \Delta Z_t) \tag{2.16}$$

$$R_t = \alpha_0 + \alpha_1 R_{t-1} + \alpha_2 Growth_t + \alpha_3 Growth'_t + \alpha_4 DisRat_t + \alpha_5 (r - r')_{t-1} \tag{2.17}$$

where a prime stands for foreign economy; and r is the real long-term interest rate. Notably, the difference between domestic and foreign long-term interest rates proxies for short-run changes in the fundamentals ΔZ_t. $Growth$ is the moving average of GNP which proxies for the productivity growth; and $DisRat$ is the ratio of private and government consumption to GNP which proxies for the consumption discount rate. $Growth$ and $DisRat$ are fundamental factors in the model. The predicted value of R is used as a measure of NATREX. Variables are measured in terms of moving averages and cyclical elements are eliminated. Nevertheless, the ratio of the social consumption to GNP and the real interest gap might still contain cyclical factors, and thus the fitted value of the model (Equation 2.17) could track the movement of short-run ERER rather than the medium one (Black, 1994; P. J. Montiel, 1999a). Importantly, the NATREX framework determines simultaneously the values of equilibrium current account balance and the ERER. This distinguishes the NATREX framework from the FEER and DEER methods in which equilibrium current account balance is a prerequisite to estimate the ERER.

Haque and Montiel (1999) proposed a general equilibrium method to estimate the long-run ERER for developing countries. They relied on an extension version of the Mundell-Fleming open economy model with a fixed exchange rate, which could be simulated to derive the steady state value of the ERER if the permanent values of other fundamental factors were known. Notably, the equilibrium model parameters were assigned representative values for a

[10] The optimization problem is to maximize the present utility of per capita consumption over an infinite period

particular developing economy instead of being empirically estimated. They then selected a base year at which the RER equal the long-run ERER. The simulated values of the long-run ERER were then adjusted corresponding to the base-year residual. In general, the general equilibrium framework developed by Haque and Montiel (1999) has less cumbersome calculation than FEER, BEER and NATREX, whereas it contains more subjective content.

Barisone, Driver, and Wren-Lewis (2006) pointed out two main characteristics distinguishing the general equilibrium approach from the PPP-based approach. Firstly, the general equilibrium approach works under the assumption of an imperfectly competitive market whereas the PPP-based approach requires perfect arbitrage that ensures the convergence of the RER. Secondly, the general equilibrium approach examines the ERER in medium term, e.g. the ERER is considered as being subjected to the capital flow balance instead of the international reserve stock equilibrium, whilst the PPP-based approach considers the ERER as a steady state value.

2.3.5 The reduced equation approach

2.3.5.1 Conventional regression methods

Despite that the general equilibrium approach having an advantage of being constructed by a strong theoretical platform, it is not capable of being applied in most of developing countries where statistical data are often not available to simulate a general equilibrium macroeconomic model. Moreover, because general equilibrium macroeconomic models are essentially constructed by linearising the evolution of a point in the vicinity of the steady state, they could generate huge measurement errors when being applied to developing economies that have low levels of economic development. For empirical purposes, the reduced equation approach is most popular in estimating the ERER in the developing countries due to its simplicity and feasibility.

Edwards (1988) developed a well-known theoretical model analysing the behaviour of the RER. He classified the equilibrium of the RER into the short-run and long-run states. While both nominal and real factors could affect the RER in the short run, only real factors drive the long-run RER. He argued that since the long-run ERER is the level at which both internal and external balances are obtained, it should be subjected to evolution of real factors. Based on the Mundell-Fleming model for a small and open economy, he identified a set of determinants of the ERER, including external factors (e.g. the terms of trade, international transfers and the world interest rate) and internal factors (e.g. imports and exports tariffs, exchange rate and capital controls, taxes and subsidies, the composition of government expenditure and technological progress). The ERER was estimated by a reduced form equation as below:

$$\begin{aligned}\log ERER_t = \beta_0 + \beta_1 \log TOT_t + \beta_2 \log NGCGDP_t \\ + \beta_3 \log TARIFFS_t + \beta_4 \log TECKPRO_t \\ + \beta_5 KAPFLO_t + \beta_6 \log OTHER_t + \varepsilon_t \end{aligned} \quad (2.18)$$

where TOT is the terms of trade; $NGCGDP$ is the ratio of government expenditure on non-tradables to GDP; $TARIFFS$ is the level of import tariffs; $TECKPRO$ is a measure of technological progress; $KAPFLO$ is capital inflows; and $OTHER$ is a vector of other fundamentals, e.g. the ratio of investment to GDP. Furthermore, based on his early research (Edwards, 1988), Edwards (1989) conceptualised the RER misalignment as the divergence of the actual RER from its equilibrium level. The RER misalignment was, therefore, attributed to the short-run monetary effects.

Similar to Edwards (1988)'s framework, Cottani et al. (1990) developed an ERER reduced-form equation as below:

$$\begin{aligned}\log RER_t = \beta_0 + \beta_1 \log TOT_t + \beta_{31} \log(Y/(X+M)_t) \\ + \beta_3 k_t + \beta_4 d_t + \beta_5 t + \varepsilon_t \end{aligned} \quad (2.19)$$

where TOT is the terms of trade; $Y/(X+E)$ is the ratio of output to the trade volume which proxies for trade policy restrictions; k is the net capital inflows measured as percentages of GDP; d is the domestic credit expansion rate in excess of the nominal exchange rate devaluation, the foreign inflation rate and the real GDP growth rate; and t is the time indicator added to control the improvement of productivity. The changes in the terms of trade and productivity were considered as exogenous non-policy factors accounting for the movement of the ERER whereas the other factors were the sources of the RER misalignment. In order to measure the RER misalignment caused by the capital flows, Cottani et al. (1990) used the expected 3-year moving average rates of GDP growth and foreign inflation. The real interest rate was estimated by subtracting the expected rate of foreign inflation from the nominal lending rate. In the year when the real interest rate was lower than the growth rate, net capital inflow was considered as sustainable. Otherwise, net capital inflow was justified as non-sustainable and the sustainable level would be assigned to be zero. Regarding to the effect of trade policies, an average of the three lowest value of $Y/(X+M)_t$ was computed (corresponding to the highest openness period) was computed, demoted as $min(Y/(X+M)$. Countries were grouped with respect to their estimated coefficients in individual country regressions in order to make set of coefficients manageable. The OLS estimator was then applied for the pooled sample of each group of countries. Based on the estimated coefficients, the RER misalignment was subsequently computed using the following equation:

$$MIS_t = \exp[-\hat{\beta}_2 \log\left((Y/(X+M)_t)/min(Y/(X+M))\right) - \hat{\beta}_3\hat{k}_t - \hat{\beta}_4 d_t] \quad (2.20)$$

In a well-known reduced-equation based study, Dollar (1992) estimated the RER misalignment for 95 developing countries over the period 1976 – 1985. In his model, the Balassa effect is the single factor driving the ERER. Using per capita income as a measure of productivity, he regressed the RER on the per capita income ($GDPH$), time dummies (T) and region dummies (R). Finally, the RER misalignment (MIS) was computed by the ratio of the actual RER to the fitted values of the ERER model:

$$RER_{it} = \alpha + \beta_1 GDPH_{it} + \beta_2 GDPH_{it}^2 + \sum_{s=1}^{t} \gamma_s T_s + \sum_{u=1}^{n} \delta_u R_u + \mu_{it} \quad (2.21)$$

$$MIS_{it} = RER_{it}/\widehat{RER_{it}} \tag{2.22}$$

Elbadawi (1994) further developed Edwards (1988)'s method by incorporating expected movements of real factors into the ERER equation. For that reason, his model was sometimes named the forward-looking ERER model. In essence, effects on the ERER of real factors were examined through an error correction model. The model had a reduced form equation as below:

$$\begin{aligned}\Delta log(ERER_t) = \beta_0\big(\delta F_{t-1} - log(\,ERER_{t-1})\big) + \beta_1 \Delta F_t \\ - \beta_2 \Delta log(RER_t) + \beta_3 \Delta \log(Cred/GDP)_t \\ + \epsilon_t\end{aligned} \tag{2.23}$$

where $Cred$ is the domestic credit volume; F is a vector of real factors, namely the terms of trade, openness, net capital inflows and government consumption; and ϵ is the one–step-ahead forecast error of $log(RER)$. Elbadawi (1994) examined the stationarity property of time series and estimated a cointegration vector by the method developed by Engle and Granger (1987)[11]. The ERER was measured as the sum of the product of real factor variables and their respective coefficients in the co-integration vector. Notably, when other cointegration estimation techniques rather than Engle and Granger (1987)'s test, e.g. Johansen cointegration test (Johansen, 1991; Johansen & Juselius, 1990), which allow multiple cointegration vectors is applied, more than one cointegration vector could be found. As a result, Elbadawi (1994)'s framework could result in more than one ERER.

Razin and Collins (1999) developed a well-known method to construct an indicator of the RER misalignment. Based on the IS-LM model for an open economy, the equilibrium RER was referred to the level at which the economy simultaneously obtains full employment and equilibrium balance of payments. They pointed out that the RER misalignment is originated from short-term rigidities associated with a range of shocks on output, demand and money

[11] The Engle and Granger (1987)'s single-equation cointegration model could be not appropriate for this multivariable system as multiple longrun relationships could exist.

supply. The fundamental factors in their model included output supply, the structure of the aggregate demand and the world interest rate. The RER misalignment (MIS) was estimated by the following equation system:

$$RER_{it} = \alpha_1 TOT_{it} + \alpha_2 RBY_{it} + \alpha_3 MG_{it} + \alpha_4 KY_{it} + \alpha_5 GYL_{it} + \beta_1 SHOCKY_{it} + \beta_2 SHOCKA_{it} + \beta_3 SHOCKM_{it} + \mu_{it} \quad (2.24)$$

$$MIS_{it} = \widehat{\beta_1} SHOCKY_{it} + \widehat{\beta_2} SHOCKA_{it} + \widehat{\beta_3} SHOCKM_{it} + \widehat{\mu_{it}} \quad (2.25)$$

Where TOT, RBY, MG, KY, GYL are, respectively, trend values of the terms of trade, the ratio of international reserves to GDP, the difference between the money supply growth rate and the GDP growth rate, the ratio of net long-term capital inflows to GDP, and the growth rate of GDP per worker. The above variables are fundamental factors. $SHOCKY, SHOCKA$ and $SHOCKM$ are, respectively, the cyclical components of GDP, absorption[12] and money supply.

Elbadawi and Soto (1997) extended the intertemporal analysis framework advanced by Edwards (1988) and took into account the effect of financial flows and sovereign risk on the ERER. Based on results drawn from the theoretical model, they specified an empirical model to estimate the ERER as below.

$$\log RER_t = \beta_0 + \beta_1 \log TOT_t + \beta_2 \log GOV_t + \beta_3 \log OPEN_t + \beta_4 \left(r_t^* + r_{A_t}\right) + \beta_5 \log NKI_t + \beta_6 \log PIV_t + \varepsilon_t \quad (2.26)$$

where TOT is the terms of trade; GOV is the ratio of government spending to GDP; $OPEN$ is the openness measured by the ration of the sum of imports and exports to GDP; r_t^* is the world interest rate; r_A is a country's sovereign risk indicator; NKI is the ratio of longterm capital inflows to GDP; and PIV is the ratio of public investment to GDP. Elbadawi and Soto (1997) employed the

[12] Absorption is the ratio between the volumes of domestically consumed products to the volumes of domestically produced products. It can be measured as the ration of GDP plus imports minus exports to GDP.

two-step procedure developed by Engle and Granger (1987) to examine the cointegration of ERER and fundamental factors in Equation (2.26). The ERER could be computed by substituting the permanent components of fundamental factors into the estimated cointegration vector. The time series of the fundamental factors were decomposed into permanent and transitory components by the method developed by Beveridge and Nelson (1981) and Newbold (1990). The estimated intercept in Equation (2.26) was adjusted based on an assumption that the observed RER is closest to the ERER when the transitory components of fundamental factors estimated are smallest.

Following Elbadawi and Soto (1997), Elbadawi, Kaltani, and Schmidt-Hebbel (2008) specified a micro-founded general equilibrium model of the RER as below:

$$\begin{aligned}\log(RER)_{it} = \beta_{0i} &+ \beta_1 \log(TOT)_{it} \\ &+ \beta_2 \log(PROD)_{\mathrm{it}} + \beta_3 OPEN_{\mathrm{it}} \\ &+ \beta_4 \log(GOV)_{\mathrm{it}} + \beta_5 \log(TAX)_{\mathrm{it}} + \beta_6 AID_{\mathrm{it}} \\ &+ \beta_7 NFI_{\mathrm{it}} + \beta_8 NPC_{\mathrm{it}} + \varepsilon_{\mathrm{it}}\end{aligned} \quad (2.27)$$

where TOT is the terms of trade; $PROD$ is the ratio of a country's per capita income to the average of OECD countries' per capita income; $OPEN$ is a trade openness indexed by the residuals derived from a regression in which the ratio of trade to GDP is regressed on geographic factors. GOV, TAX, AID, NFI and *NPC* are respectively the ratio of government spending, taxes on non-traded goods, net foreign aid, net foreign income and net private capital inflows to GDP. The ERER was computed as the fitted values of the model (2.27) at which explanatory variables were assigned their trend values.

2.3.5.2 The cointegration method

There is another major part of the literature in which the cointegration method is employed to examine a reduced equation instead of the conventional regressions. This approach was initiated by Faruqee (1995) and then named as the behaviour equilibirum real exchange rate (BEER) by Clark and MacDonald (1999).

Faruqee (1995) relied on a stock-flow perspective to specify an empirical model which featured the long-run relationship between the RER, net foreign assets (NFA) measured as percentage of GNP, the terms of trade (TOT) and productivity ($PROD$). Two alternative indices of productivity were used in the model. The first index was constructed as the ratio of a country's relative price of traded to non-traded goods to the corresponding for G7 countries. The second index was the ratio of a country' growth rate of output per man-hour in manufacturing to the corresponding for G7 countries.

$$REER = \beta_0 + \beta_1 NFA + \beta_2 TOT + \beta_3 PROD + \mu \tag{2.28}$$

The long-run relationship between variables was examined by using the Johansen cointegration test (Johansen, 1991; Johansen & Juselius, 1990). In the case that a long-run relationship existed, a cointegration vector could be derived and used to compute the trend components of the REER, which was considered as the BEER. Notably, this framework is subjected to the ambiguity in selecting a cointegration vector to compute the BEER as it is possible to have more than one cointegration vector in a multivariable system. To tackle this issue, Faruqee (1995) recommended using the cointegration vector corresponding to the maximal eigen-value in the Johansen cointegration test and considered that it reflected the dominant long-run relationship. Nevertheless, he took into account the consistency between the actual and expected signs of the cointegration vector coefficients, and the plausibility of the magnitude of the vector coefficients as well. In a later study, Cour and MacDonald (2000) suggested using an aggregate vector which was the sum of all normalised cointegration vectors.

Clark and MacDonald (2004) argued that the value of fundamental factors in the BEER model could include cyclical components. They suggested a procedure to compute the permanent equilibrium real exchange rate (PEER) which was determined by the permanent components of fundamental factors. They applied the Gonzalo and Granger (1995)'s procedure which relied on the Johansen cointegration method to extract the permanent components of cointegrated series, to derive the PEER. Notably, the empirical results showed that the BEER and PEER seem not always to move closely together.

Nouira and Sekkat (2012) presented a thorough strategy to estimate BEER. Rather than using the RER, they employed the REER, which was calculated by considering a country's 10 largest non-oil exporting trade partners. They estimated the following equation:

$$\begin{aligned}\text{Log}(REER) = \alpha_0 &+ \alpha_1\text{Log}(Open) + \alpha_2\text{Log}(Cap) \\ &+ \alpha_3\text{Log}(TOT) + \alpha_4\text{Log}(rDebt) \\ &+ \alpha_5\text{Log}(GOV) + \alpha_6\text{Log}(GDPgap) \\ &+ \alpha_7\text{Log}(BalSam) + \varepsilon \end{aligned} \quad (2.29)$$

where $Open$ is trade openness measured as the sum of exports and imports scaled by GDP; Cap is the ratio of the net capital inflows to GDP; TOT is the terms of trade; $rDebt$ is the ratio of debt services including interest payments and reimbursements to GDP; GOV is the ratio of government consumption to GDP; $GDPgap$ is the difference between a country's growth rate and the average rate of the whole sample; and Bal is the ratio of a country's per capita GDP to geometric mean of its trading partners' per capita GDP which is weighted by the trade scheme used to estimate REER.

Regarding the roles of explanatory variables in determining the ERER, Nouira and Sekkat (2012) argued that a higher level of trade openness could put pressure on the relative price of tradables to non-tradables and thereby depreciate the ERER. The terms of trade could affect the ERER through the income effect and substitution effect channels. A rise in the terms of trade could increase the ERER if the income effect dominates the substitution effect. Higher capital inflows increase demand for both tradables and non-tradables. While higher demand for tradables can be achieved by adjusting the current account, higher demand for non-tradables requires domestic resources to be diverted toward the non-tradables production sector. This eventually increases the relative price of non-tradables and hence appreciates the ERER. Similarly, government spending appreciates the ERER by creating demand on non-tradables. The debt service affects the ERER through a mechanism similar to but in the opposite direction to capital inflows. The variable Bal represents the productivity gap and proxies for the Balassa effect.

To estimate the BEER, Nouira and Sekkat (2012) firstly examined the cross-section dependence of variables. The cross-section dependence test developed by Pesaran (2004) was conducted and it was found that all variables are cross-section dependent. In the next step, Pesaran (2007)'s unit root test for a cross-section dependence panel was used to explore the integrated order of variables. Since all variables were found to be first-difference stationary, the panel data cointegration test advanced by Pedroni (2004) was conducted and the result indicated that the variables are cointegrated. Finally, the dynamic OLS estimator proposed by Kao and Chiang (2000) was used to derive the cointegration vector.

Egert and Halpern (2006) applied the meta-regression analysis approach to inspect the consistence of RER misalignment estimation results in the literature. They surveyed 32 studies, both published and unpublished, which estimated Central and Eastern Europe countries' RER misalignment using various econometric techniques and theoretical approaches such as PPP-based, the BEER , the PEER and the FEER. They found that there are structural differences in the RER misalignment estimation results. In other words, alternative theoretical frameworks and regression techniques would yield largely different RER misalignment estimation.

2.4 Summary

Measuring accurately the RER misalignment is essential for empirically examining the economic consequences of the RER misalignment. Unfortunately, there are a number of empirical problems complicating the measurement of the RER misalignment. This chapter reviews two sets of empirical problems related to estimating the RER and the ERER.

There are different approaches to define the RER, e.g. the internal and external approaches, and each of them motivates the use of a different price index. In fact, there is no perfect price index to estimate the RER and each price index has its own advantages and disadvantages. Moreover, estimates of the RER appear to be largely subject to the price index used. Besides the ambiguity in selecting a price index, estimating the multilateral RER particularly faces the empirical problems of determining a trading-weight scheme, identifying the scales of parallel good and exchange markets, and adjusting for the third-country issue.

The concept and measurement of the ERER are even more puzzling. The conventional PPP theory receives very little support from the empirical literature and that motivates a new approach to define the ERER. New insights into the nature of the ERER have been provided in Stein (1994)'s NATREX model which classifies the ERER in the short-, medium- and long-terms. The medium-term ERER has been of most interest in recent literature and there are a variety of approaches developed to estimate the ERER in the medium-term, namely the partial equilibrium approach, general equilibrium approach and equation-based approach. While the two first approaches are based on assumptions of economic parameters rather than statistical data, the last approach seems to lack theoretical foundation.

CHAPTER 3

THE REAL EXCHANGE RATE MISALIGNMENT AND ECONOMIC GROWTH

3.1 Introduction

This chapter aims to provide an overview on the current state of knowledge on the relationship between the RER misalignment and economic growth. While the correlation between the RER and economic growth has been long investigated by economists, the literature on growth effect of the RER misalignment has just developed during the last two decades. The literature has so far mostly focused on the empirical phenomenon of this relationship and to some extent, neglected theoretical aspects.

In order to grasp the development of this thread, this chapter starts by reviewing theoretical works explaining the causal effect of the RER misalignment on economic growth. It also takes into consideration studies on practical policy-making issues, e.g. whether a government can target and make use of a favourable RER. In the next part, seminal empirical studies are reviewed with a focus on estimation strategies, samples and empirical results. Notably, special interest is paid to empirical studies carried out in East Asian countries. Efforts are also devoted to review the empirical literature on the channels through which the RER misalignment affects economic growth, e.g. productivity and capital formation channels.

Since econometric techniques have been rapidly advanced over time, empirical analysis in decades-old studies could exhibit flaws that might seriously affect the validity of reported results. In order to obtain an accurate perspective on the empirical relationship between the RER misalignment and economic growth, this chapter attempts to evaluate and assess the robustness of reported evidence. Comments and notes, which are mostly related to empirical methodologies in reviewed studies, are appropriately provided. The remainder of this chapter includes three parts. Section 3.2 reviews theoretical studies, Section 3.3 focuses on empirical research, and finally, Section 3.4 provides the Summary.

3.2 The theoretical literature

Conventional economic theories present a skeptical view on the relationship between economic growth and the RER misalignment. There is doubt that the RER misalignment really exists, and that even if it does exist then it would just be a transitory phenomenon and not have substantial influence. Neoclassical economics typically considers the devaluation rate of a nominal exchange rate as a nominal anchor to which the growth rates of other nominal economic variables tend to converge. This implies that the RER misalignment could only exist in transitional periods. Furthermore, there are well-known Keynesian economics balance of payment models (e.g. Dornbusch, 1973; Frenkel & Rodriguez, 1975; Mundell, 1971; Mussa, 1974) asserting that it is unfeasible to retain a misaligned exchange rate. It is argued that a policy retaining a country's overvalued domestic currency would exhaust its reserves, whereas the effort to depreciate the domestic currency could lead to higher domestic price level and thus the RER eventually moves to the equilibrium level.

For that reason, early literature mostly focused on analysing the short-run growth-effect of the RER rather than longer-term effect of the RER misalignment on economic growth. In the Keynesian economics context, a real devaluation is associated with higher domestic output because of higher foreign demand for domestic exportable goods. However, it is also pointed out that a real devaluation could lead to output contraction in some particular situations. For example, based on a small and open economy model, Alejandro (1963) showed that a real devaluation could have negative effect on economic growth in the short run. He made strong assumptions that the supply of tradables is inelastic whereas the supply of non-tradables is elastic. Thus, the domestic demand for non-traded goods could decide the level of domestic output. He claimed that a real devaluation tends to increase the real income of capitalists while reducing the real income of workers. If the marginal propensity of workers to consume non-tradables is larger enough than the propensity of capitalists, this income distribution effect would offset the substitution effect caused by a lower relative price of non-tradables to tradables. Eventually, domestic demand for non-tradables and domestic output both decrease.

In addition to the income distribution effect discussed by Alejandro (1963), Krugman and Taylor (1978) analysed the roles of the initial trade balance level and government spending in determining the short-run growth effect of a real devaluation. They found out that a real devaluation could have negative (positive) effect on output if the trade balance is initially deficit (surplus). Moreover, it could influence output through the fiscal effect channel. That is, the government revenue could improve if the income tax rate on capitalists' profits is higher than that of workers' wages. Because the saving propensity of government equals unity in the short run, higher government revenue implies more saving, less aggregate demand, and eventually lower output.

On the neoclassical economics side, qualitative analyses on the role of the RER misalignment generally emphasises the resource allocation effect. For example, Willett (1986) argued that an overvalued currency could be considered equivalently as imposing a tariff on exports and a subsidy on imports. Inversely, an undervalued currency could be similar as a tariff on import and a subsidy on exports. Thus, both overvalued and undervalued distortions could bear economic costs and affect economic growth negatively. Besides, the RER misalignment could also cause wrong signals to firms and other economic agents, and amplify economic instability.

However, the policy practices in targeting a competitive exchange rate in developing countries have challenged the conventional beliefs. For example, the PPP-rule policy, which attempts to devaluate a country's nominal exchange rate at a pace faster than its inflation, was applied in three Latin American countries: Brazil (1968-1993), Chile (1985-1992), and Colombia (1985-1990) to obtain competitive RERs and to some extent, gained considerable success (Calvo, Reinhart, & Végh, 1995). In particular, much attention has recently been drawn in the case of China, which is accused of manipulating its domestic currency during the two last decades to support economic growth (Rodrik, 2008). These observations seem to hint that government intervention could play a significant role in retaining a competitive exchange rate over a sufficiently long period to influence economic growth.

The feasibility of a government in targeting a depreciated RER was theoretically analysed by Calvo et al. (1995) who developed an intertemporal optimisation model in which a representative consumer maximises his utility derived from consuming a mix of tradables and non-tradables. The representative consumer’s budget was assumed to be constrained by fixed endowments of tradables and non-tradables outputs. Firstly, they found that the steady state level of the RER would be independent of a constant rate of nominal devaluation if there were perfect capital mobility. That is, a change in the rate of nominal devaluation merely has a transitional effect, and inflation adjusts to a rate to offset such change. Thus, a depreciated RER could only be targeted in a certain period rather than in the long run. Secondly, if there were capital immobility, a depreciated RER would be generated temporarily by continually increasing the nominal interest rate. Increasing inflation can be avoided in this case, and yet the nominal interest rate must keep increasing until the RER returns to its equilibrium level. Calvo et al. (1995) concluded that monetary policies have no effect on the RER in the long run.

In a following analysis, Eichengreen (2007) shared Calvo et al. (1995)’s viewpoint that monetary policies are incapable of sustaining a certain level of the RER. Although the price level is often sluggish to a shock, nominal variables such as the nominal exchange rate and inflation will finally react and obtain initial relative prices. Unlike monetary policies, fiscal policies as argued by Eichengreen (2007) could have sustainable effect on the RER. For example, if government spending tends to fall on non-tradables, an expansionary fiscal policy would increase the relative price of non-tradables to tradables and hence appreciate the RER. Thus, even though the RER is not under full control of a government, it can be partly directed by a set of appropriate policies.

Understanding of the RER misalignment has been significantly advanced by the introduction of the general equilibrium approach (i.e. Bayoumi et al., 1994; Elbadawi, 1994; Stein, 1994; Williamson, 1994) which defines the RER misalignment in the medium-term rather than the short- or long-term. Unlike conventional neoclassical or Keynesian economics approaches, which consider government interventions as the only source of the RER misalignment, the general equilibrium approach emphasises the medium-term RER misalignment as the result of speculative and cyclical factors, and the movements of fundamental factors. The RER misalignment, therefore, could exist not only in fixed exchange rate regimes but also in the floating regimes with perfect capital mobility, even without the consequences of exchange rate manipulating policies.

Nevertheless, although there is a large part of the literature that attempts to search for statistical evidences of the growth-enhancing effect of the RER misalignment, not much effort has been devoted to explore how this effect would be generated. In a pioneering study, Rodrik (2008) developed a two sector economy model to illustrate the mechanics of the growth-enhancing effect of the RER misalignment. He argued that the tradables and non-tradables sectors suffer disproportionately from government or market failures. For instance, taxes are often higher on the tradables than the non-tradables. Such failures lead to a suboptimal state of the economy since resources are misallocated. The size of the tradables sector tends to be small because it receives less resources. An undervalued RER could facilitate economic growth as it counterbalances negative effect of government or market failures on the tradable sector. Notably, Rodrik (2008)'s model essentially relies on an particularly restrictive assumption that the tradables sector suffers more from the government or market failures than non-tradables while this assumption is often criticised as not sensible (e.g. Henry & Woodford, 2008).

Gala (2008) discussed channels through which the RER could influence economic growth in the context of Keynesian economics. His model was essentially based on the assumption of nominal wage rigidity. He argued that because the nominal wage is fixed, a real devaluation, which increases the relative price of tradables to non-tradables, could reduce the real wage and then raise firms' profit margins. Since investment is a positive function of profit margins, a real devaluation could eventually promote investment. This is the way that "investment-led growth" works out. Regarding "consumption-led growth", if investment is elastic enough to profit margin change, an increase in investment could compensate for declined consumption demand. Thus, aggregate demand could be enlarged by a real devaluation. In contrast, when the elasticity of investment to profit margin change is small, a real devaluation could be recessionary. The impact of a real devaluation on economic growth becomes more important when the installed capacity constraints are introduced into the model. In this case, economic growth depends extensively on the investment-enhancing role of real devaluation.

P. Montiel and Serven (2008) summarised two dominant views on the channel through which the RER misalignment could affect economic growth. The first view emphasises the role of a depreciated RER in shifting production from the non-tradables sector to the tradables sector. Since the tradables sector generates productivity improvements through the "learning by doing" process, e.g. technology and skill transfers, a depreciated RER could create external effects to productivity growth. The second view advocates the investment-enhancing effect of a depreciated RER. This capital accumulation channel works out in two ways. First, a depreciated RER could stimulate the domestic saving rate and thereby increase the rate of capital accumulation. Second, it could raise profitability in the tradables sector, which is likely to be capital-intensive. Higher profitability then causes a higher level of investment in the tradables sector. Notably, Montiel and Servén (2008) carried out an intertemporal analysis and found that there is not a link between the RER and domestic saving.

Porcile and Lima (2010) examined the influence of a depreciated RER on economic growth in a balance of payments constrained macro-dynamic model. The starting point of their model is that foreign and domestic capital goods must combine in fixed proportions in production. Thus, economic growth depends on foreign currency availability for importing foreign capital goods. Because of a restricted capital account, the equilibrium of balance of payments requires that imported capital goods must be financed by exports of domestic goods, which in turn depends on the RER. As a result, a depreciated RER could release the balance of payments constraint and stimulate economic growth.

3.3 Empirical literature

In an early study, Cottani et al. (1990) argued that the RER misalignment could change the relative prices of products and influence profitability of some industries. This distortion could negatively affect economic growth, especially when the RER misalignment takes a form of overvaluation because the tradables sector in which productivity improvements are more likely to take place is hurt. Cottani et al. (1990) empirically investigated the relationship between the RER misalignment and economic growth in a sample consisting of 24 developing countries over the period 1960-83. The RER misalignment was estimated by the reduced equation approach (details are provided in Chapter 2). The OLS estimator was applied to estimate a cross-country growth model in which economic growth is a function of the RER misalignment and the RER instability. They found significant evidence supporting a negative correlation between overvaluation and economic growth. Because the Cottani et al. (1990)'s model is linear, the results could equivalently be interpreted that undervaluation has a positive effect on economic growth. Importantly, Cottani et al. (1990) highlighted that this empirical finding does not necessarily imply a causal effect of the RER misalignment on economic growth as the co-movement between two variables could probably result from exogenous shocks.

Dollar (1992) conducted a seminal empirical study in which he estimated the RER misalignment for 95 developing countries over the period 1976 – 1985 using the reduced-equation approach and then investigated the relationship between the RER misalignment and economic growth through an empirical economic model. Similar to Cottani et al. (1990), he used the OLS estimator to regress per capita GDP growth on a set of explanatory variables including the RER misalignment, the RER variability, investment volume and regional dummy variables. Variables in Dollar (1992)'s model were in the form of 10-year average series. The empirical results indicated that overvaluation (devaluation) has significant and negative (positive) effect on economic growth.

Ghura and Grennes (1993) investigated the influence of the RER misalignment on economic performance in 33 countries in Sub-Saharan Africa over the period 1972-87. In order to estimate the RER misalignment, they followed Cottani et al. (1990)'s reduced-form equation framework but the instrumental variable (IV) estimation method was used instead of the OLS estimator. Other than that, two other alternative measures of the RER misalignment were considered. One was the conventional PPP-based rate. The other was calculated by the difference between the parallel market exchange rate and the official exchange rate. A growth model, which used the RER misalignment as an explanatory variable, was then specified. Also, there were a set of control variables including the investment to GDP ratio, population growth and the terms of trade. Because the investment to GDP ratio was assumed to be an endogenous variable, the IV method was applied to estimate the growth model. They found significant evidence supporting a negative (positive) relationship between overvaluation (undervaluation) and economic growth. Subsequently, sensitivity analyses were conducted, and the results indicated that this relationship is consistent across models employing different RER misalignment measures. Moreover, the RER misalignment index estimated by the reduced-form equation framework appeared to perform better than two other measures in explaining the fluctuation of economic growth.

Based on the sample comprising 93 countries over two periods 1975-1983 and 1984-1992, Razin and Collins (1999) explored the relationship between the RER misalignment and economic growth through the following growth model:

$$GYPC = \gamma X + \delta MIS + \varphi D + \mu \tag{3.1}$$

where $GYPC$ is the growth rate of per capita GDP; X is a vector of control variables which are the ratio of government expenditure to GDP, the standard deviation of the terms of trade, changes in the terms of trade, life expectancy, the primary school enrollment rate, the secondary school enrollment rate, and the initial income level; MIS is the RER misalignment; and D is a vector of regional dummy variables. A linear relationship between the RER misalignment and economic growth appeared to be not statistically significant. To search for a non-linear relationship, Razin and Collins (1999) split the sample into eight groups, namely very high, high, medium, and low degrees of overvaluation and undervaluation. They found that very high overvaluation could hinder economic growth whereas high undervaluation seems to have positive effect. Besides, the impact on economic growth of the other groups was not statistically significant.

However, it is noteworthy that in early studies such as Cottani et al. (1990), Dollar (1992) and Razin and Collins (1999), the statistical correlation between the RER misalignment and economic growth, which was derived from cross-country regressions, could be seriously affected by the endogeneity issue (Rodrik, 2012).

Shabsigh and Domac (1999) inspected the RER misalignment and economic growth nexus in four Middle East countries: Egypt, Jordan, Morocco, and Tunisia using annual data from 1970 to 1995. Following Ghura and Grennes (1993), they estimated three different indices of the RER misalignment which were the PPP-based index, the index derived from Cottani et al. (1990)'s reduced equation method, and the index measured by the difference between the parallel market and official exchange rates. Subsequently, a growth model was specified in which real income growth is a function of the RER misalignment, the RER variability, the ratio of investment to GDP, changes in the term of trade, and population growth. To tackle the endogeneity problem that investment and income growth could be endogenous, the three-stage least square (3SLS) estimator was applied. A linear relationship between the RER misalignment and income growth was supported by consistent estimation results across models using alternative RER misalignment indices. This indicates that overvaluation and undervaluation respectively have negative and positive effects on economic growth. Especially, the RER misalignment index measured by the Cottani et al. (1990)'s reduced-equation approach has a considerably larger coefficient than the two other RER misalignment indices.

Bleaney and Greenaway (2001) examined the role of the RER misalignment in determining investment and growth in 14 Sub-Saharan African countries, using annual data over the period 1980-95. The RER misalignment was estimated by the reduced-form equation framework developed by Edwards (1989). An investment determinant model in which the RER misalignment was an independent variable was estimated. A set of variables was used to control for exogenous shocks, including the lags terms of dependent variables, GDP growth, the terms of trade, the volatility of the terms of trade and the RER volatility. Similarly, a growth determinant model was specified in which the explanatory variables were the RER misalignment, the initial level of GDP, the terms of trade and the volatility in the terms of trade. Notably, contemporary terms of the explanatory variables were dropped in both investment and growth determinant models to avoid potential endogeneity. The panel fixed-effect regression showed evidence supporting the negative (positive) effect of overvaluation (undervaluation) on investment and economic growth. According to Bleaney and Greenaway (2001), overvaluation could worsen the current account balance, and cause authorities to tighten import licensing procedures and implement tightening macroeconomic policies. This could eventually reduce investment return and raise the shadow price of capital goods. For that reason, overvaluation could hinder investment in spite of cheaper imported capital goods.

Acemoglu, Johnson, Robinson, and Thaicharoen (2003) examined the relationship between economic growth, an overvalued exchange rate and institutional fundamentals. They argued that a country pursues distortionary macroeconomic policies such as an overvalued exchange rate because it has weak institutions that finally lead to poor economic performance. Therefore, the correlation between a misaligned exchange rate policy and economic growth might not be a causal relationship as institutional factors could be the original cause of both slow economic growth and overvaluation. Unfortunately, those relationships are difficult to be empirically verified because of the endogeneity issue that there is obviously strong feedback from economic growth and distortionary macroeconomic policies to institutional quality.

In order to address this endogeneity problem, Acemoglu et al. (2003) proposed the use of the historic mortality rate of settlers as an instrument for institutional factors in colonial countries. In the empirical analysis, they looked at three indices of economic performance including the volatility of economic growth, the worst output drops and the average growth rate. Following the equation-based framework advanced by Dollar (1992), they estimated overvaluation indices in 73 ex-colony countries over the period 1970-97. The institutional factor was measured by the executive constraint index that counts the number of institutional and other constraints placed on a country's president and dictator. A number of empirical growth models were specified, and results of the cross-section regressions demonstrated consistent evidence on the negative effects of overvaluation on economic growth and growth volatility. Moreover, to examine that whether such effects of overvaluation are merely the surface symptoms of institutional problems or that overvaluation has independent effects, the institutional variable was added into the growth models. The 2SLS computational method was applied to calculate the IV estimates. Interestingly, it was shown that the coefficients of overvaluation remain significant in the growth models with the institutional variable added. According to Acemoglu et al. (2003), this result implies that overvaluation is probably not the primary mediating channel of the institutional factors, and that it is likely to have an independent effect on economic growth.

Aguirre and Calderon (2005) presented an extensive study on the effect of the RER misalignment on economic growth in 60 countries over the period 1965-2003. They made use of three different measures of the RER misalignment. The primary measure of the RER misalignment was obtained by estimating a reduced equation model in which the ERER determinants were the net foreign asset position, the level of per capita income, the terms of trade, and government spending. The dynamic least square (DOLS) estimator advanced by Larsson, Lyhagen, and Lothgren (2001) was used to estimate the ERER determinant model. The second method was to apply the band-pass filter technique developed by Baxter and King (1999) to decompose the actual RER series into cyclical and trend components. The RER misalignment was measured the deviation of the actual RER from its trend value. The index estimated by the framework proposed by Dollar (1992) was used as the third measure of the RER misalignment.

Having constructed the RER misalignment indices, Aguirre and Calderon (2005) specified a growth model in which the right-hand side includes the RER misalignment and a set of control variables: the initial income level, the output gap, human capital proxied by the secondary school enrolment rate, financial depth, trade openness, inflation, and currency crisis dummies. The system

GMM estimator (Arellano & Bover, 1995; Blundell & Bond, 1998) was employed and there was evidence supporting a linear relationship between the RER misalignment and economic growth. Results of regression using alternative the RER misalignment indices indicated a linear relationship that undervaluation (overvaluation) promotes (hinder) economic growth. In order to examine the asymmetric effects of overvaluation and undervaluation, the RER misalignment variables were then split into two separate variables: overvaluation and undervaluation. In detail, overvaluation (undervaluation) equals to the RER misalignment if the RER were overvalued (undervalued), and equals zero if otherwise. This led to the result that both overvaluation and undervaluation harm economic growth. This result indeed supports the standpoint of the Washington consensus. Moreover, undervaluation appears to be less harmful than overvaluation since the coefficient of undervaluation is substantially smaller than the coefficient of overvaluation. This could explain the significance of the RER misalignment in the initial growth model.

In the next step, the quadric terms of overvaluation and undervaluation was added into the growth equation in order to inspect the magnitude of the growth effect of the RER misalignment. It was found that low undervaluation could promote economic growth whereas higher undervaluation and overvaluation harm economic growth. Finally, Aguirre and Calderon (2005) investigated the interaction between overvaluation and currency crises. A currency crisis was defined as a drop, which is at least 10% larger than the devaluation rate in the previous year, of more than 25% in the official exchange rate. The coefficients of the interaction terms are negative and statistically significant. This implies that the adverse effect of overvaluation is more severe during currency crisis periods.

Hausmann et al. (2005) provided an event study on the relationship between the RER misalignment and economic growth. They looked at 83 episodes of rapid growth acceleration over the world since the 1950s. They investigated the correlation between three-year average of the RER around the start of growth acceleration and the RER at seven year prior to the growth acceleration. It was found that growth acceleration is often accompanied by previous substantial real devaluation. In order to confirm the causality of this relationship, they examined the correlation of RERs in growth acceleration episodes with RERs in previous periods. They found no statistically significant correlation between the averages of the RER in four years prior to growth acceleration and the averages of the RER in eight years after the growth acceleration. This implies that real depreciation appears to be a cause of growth acceleration.

Gala and Lucinda (2006) searched for a correlation between overvaluation and economic growth in a panel consisting of 5-year non-overlapping period observations in 58 developing countries from 1960 to 1999. They measured the RER misalignment by the framework developed by Dollar (1992) and found that Asian developing countries tend to manage their currencies to avoid overvaluation whereas their Latin American counterparts seem to pursue opposite policies. Subsequently, they estimated a growth model in which the independent variables includes the RER misalignment, the initial level of GDP per capita, schooling, infrastructure, the terms of trade, price stability and time dummies. A variety of panel data estimation techniques was applied, namely system GMM (Arellano & Bover, 1995; Blundell & Bond, 1998), difference GMM (Blundell & Bond, 1998), pooled OLS and fixed-effect OLS. The regression results appeared to be largely divergent across regressions. While there were highly significant evidences supporting for the negative (positive) effect on economic growth of overvaluation (devaluation) in the pooled and fixed-effect OLS regressions, the evidence of this relationship was less significant in the system GMM regressions, and insignificant in the difference GMM regressions.

Bhalla (2007) observed the correlation between the RER and per capita income in OECD countries and noticed that the ratio of the RER to income tends to increase over time. He suggested that this non-linear relationship could follow an S-shaped pattern. The RER almost stays constant in the beginning stage of development and starts rising as income passes a certain level. Therefore, an exponential model could be more appropriate for capturing the Balassa effect than a linear model:

$$RER = \alpha(1 - \beta^{YPC}) \quad (3.2)$$

where YPC is the per capita GDP. After estimating the Equation (3.2), Bhalla (2007) measured the RER misalignment as the difference between the actual RER and the fitted values. In order to examine the growth effect of RER misalignment, he sampled developed and developing countries, which have more than 1 million populations and are not oil-exporting, over the period 1980-2006. A variety of regression techniques including Pooled OLS, fixed effect OLS and difference GMM were applied to estimate a growth model in which per capita income is a function of the RER misalignment and the population shares of the middle class. The empirical result indicates that undervaluation and overvaluation have respectively positive and negative effects on economic growth.

Prasad et al. (2007) conjectured that capital inflows could induce overvaluation and thereby hinder economic growth. This hypothesis was empirically investigated by using a large panel consisting of 59 non-industrial countries over the period from 1970 to 2004. They derived an index of the RER misalignment by adjusting the actual RER from the Balassa effect. A country's relative price to the US was regressed on the productivity level which was proxied by per capita GDP.

$$\log p_i = \alpha + \beta \log y_i + \varepsilon_i \tag{3.3}$$

where $\mathrm{p_i}$ is the relative price level of country i to the US; and $\mathrm{y_i}$ is country i's per capita GDP. The RER misalignment was indexed by the estimated residual $(\hat{\varepsilon})$. Notably, the Equation (3.3) was estimated by cross-section regressions for each year. Per capita income growth was then regressed on the RER misalignment index and a set of control variables including the ratio of current account balance to GDP, the initial level of per capita income, life expectancy, trade openness, the fiscal balance, institutional quality, working-age shares and regional dummies. Both cross-sectional OLS, difference GMM and system GMM estimators was used to estimate the growth model. Consistent evidence supporting the negative (positive) effect of overvaluation (undervaluation) on economic growth was found.

Besides the linear relationship between the RER misalignment and economic growth, Prasad et al. (2007) examined the asymmetric impact of undervaluation and overvaluation. They added into the growth model a dummy variable capturing the structural difference in the growth-effects of overvaluation and undervaluation. Results of the extended growth model do not reject the symmetric impact of the RER misalignment on economic growth. Subsequently, they looked for evidence of the relationship between the RER misalignment and growth at the industry level. An industry value-added equation was specified as below:

$$G_{ij} = \beta_0 + \beta_1 man_{ij} + \alpha\left(MIS_j * xport_i\right) + \varepsilon_{ij} \tag{3.4}$$

where i and j are respectively the country and industry indexes; G is the growth rate of value added; MIS is the RER misalignment index; and $xport$ is the exportability index. Prasad et al. (2007) proposed two methods to measure the exportability index of an industry. In the simple way, the exportability index was assigned to be 1 for four industries: textiles, clothing, leather and footwear, and 0 for other industries. Alternatively, based on the medium value of per capita income, the sample of developing countries was divided into high- and low- income grouped in order to reduce heterogeneity. The ratio of an industry's exports to its value added was calculated and used to derive the average ratio of each group. An exportable industry was defined as one having an above-medium ratio of exports to the value added. The exportability index was assigned to be 1 in exportable industries and 0 otherwise. The panel fixed-effect OLS estimator was applied to estimate models using alternative exportability indexes. Empirical results demonstrate that the interaction between overvaluation and exportability has a negative effect on the value-added of an industry. In other words, overvaluation (undervaluation) could hinder (promote) the growth of the exports sector.

Following the framework developed by Dollar (1992), Gala (2008) estimated RER misalignment indices for 58 developing countries over the period 1960-1999. After that, he regressed income growth on the RER misalignment and a set of control variables, namely the initial level of per capita income, the initial output gap, education attainment, public infrastructure, governance quality, price instability, shocks in the terms of trade, population growth, and time dummies. A variety of regression techniques were used to estimate the growth model, including pooled OLS, fixed-effect OLS, system GMM and difference

GMM estimators. Results in the majority of regressions demonstrate significant and positive (negative) effect of undervaluation (overvaluation) on growth.

Rodrik (2008) investigated empirically the relationship between the RER misalignment and economic growth. He estimates growth equations using a sample consisting of 188 countries over 11 five-year non-overlapping periods, from 1950-1954 to 2000-2004. Economic growth was regressed solely on the RER misalignment in the baseline models, and on the RER misalignment and a set of control variables, namely institutional quality, government consumption, the terms of trade, inflation, human capital and the saving rate, in the extended models. The RER misalignment was estimated following Dollar (1992)'s approach. The difference and system GMM estimators were applied and the empirical result indicates that undervaluation (overvaluation) has significant and positive (negative) effect on growth in developing countries but has insignificant effect in developed countries. By investigating the interaction term between the RER misalignment and per capita income, Rodrik (2008) found that the positive (negative) growth-effect of undervaluation (overvaluation) diminishes as income increases. To further examine the influence of the income level, the sample was divided into a group of developing countries, which had per capita income levels of less than $6,000, and a group of the other countries. It was found that whereas the RER misalignment and growth nexus is highly significant in the developing countries, it is insignificant in the other countries. This finding was discussed by Rapetti, Skott, and Razmi (2012) who reproduced Rodrik (2008)'s analysis framework but used a different income threshold level to classify developed and developing countries. Rapetti et al. (2012) found that the effect of the RER misalignment on growth does not change monotonically according to income level. They showed that the relationship between the RER misalignment and growth remains significant in the group of countries, which have per capita income in the range $9,000 - $15,000. Moreover, they categorised 25% of countries with lowest per capita income as the low-income group, 25% of countries with top income as the high-income group, and the other 50% of countries as the middle-income group. It was found that the effect of the RER misalignment on growth is significant in the low- and high-income groups, but surprisingly insignificant in the middle-income countries.

In a review of Rodrik (2008)'s work, Henry and Woodford (2008) criticised the equation-based approach to estimate the RER misalignment as it might exaggerate the correlation between the RER misalignment and economic growth. Because the per capita income was used as a determinant of the ERER, the estimated index of the RER misalignment has statistical correlations with per capita income. Therefore, the correlation between economic growth and RER misalignment indices estimated by the equation-based approach appears to reflect the correlation between economic growth and itself. Besides, Henry and Woodford (2008) cast doubt on Rodrik (2008)'s conclusion on the causal effect of undervaluation on economic growth as both undervaluation and high economic growth might result from favourable policies. More importantly, based on the monetarist viewpoint, Henry and Woodford (2008) strongly criticised the approach that considers the RER as an exogenous variable and ignores the subsequent impacts of sterilising policies to retain an undervalued exchange rate. Finally, they noted that the positive growth effect of undervaluation, when it exists, does not guarantee the progress of social welfare and hence the social cost of excess foreign exchange reserves should be taken into consideration (Henry & Woodford, 2008).

Blecker and Razmi (2008) classified and empirically investigated two hypotheses about the short-run impact of a competitive exchange rate policy in developing countries, namely "fallacy of decomposition" and "contractionary depreciation". The former states that devaluation in a developing country against its competing developing countries boosts economic growth in the home country but hurts the competing developing countries. The latter claims that devaluation in a developing country against industrialised countries could temporarily hamper economic growth in the home country. They argued that economic expansion in developing countries is constrained by the imported capital and intermediate goods. To afford foreign exchange for the imported goods, developing countries must depend on export earnings and net capital inflows. To capture this constraint, they specified a growth model as below:

$$Y = \beta_0 + \beta_1 Y + \beta_2 R^D + \beta_3 R^I + \beta_4 F + \varepsilon \tag{3.5}$$

where Y is the output of a developing country; X is the developing country's exports of manufactured goods to industrial countries; R^I is the developing country's REER against industrial countries; R^D is the developing country's REER against competing developing countries; and F is the net capital inflows. All variables were measured as annual growth rates. Ten industrial countries that are the largest importers of manufactured products from the developing country were sampled to calculate three explanatory variables X, R^I and R^D. Alternative price indices including the export price, producer price index (PPI), and consumer price index (CPI) were used to measure REER.

Blecker and Razmi (2008) restricted the dataset to 18 developing countries that have manufactured goods accounting for more than 70% of exports. Moreover, developing countries were grouped by criteria such as the ratio of manufactured exports to GDP, GDP size, trade openness, foreign debt, and the share of high technology goods in manufactured exports. The difference GMM estimator was applied, and empirical results of estimation models supported the hypotheses of “fallacy of decomposition” $(\beta_2 > 0)$ and “contractionary devaluation” $(\beta_3 < 0)$. The empirical evidence was consistent across different regressions using the whole sample or subgroups of the developing countries examined. Especially, the “fallacy of decomposition” effect seems to be strongest for small open and low technology exporting economies whereas the “contractionary devaluation” effect is strongest in countries with high external debt levels.

Elbadawi et al. (2008) empirically investigated the effect on economic growth of the RER misalignment and its interactions with foreign aid and financial development. They sampled data from 39 conflict and 44 non-conflict developing countries over the period 1970-2004. The following growth model was estimated:

$$\dot{y}_{it} = \beta_0 A_{it} + \beta_1 A_{it}^2 + \beta_2 MIS_{it} + \beta_3 FD_{it} + \beta_4 A_{it} * MIS_{it} + \beta_5 FD_{it} * MIS_{it} + \theta_1 TD_{it} + \theta_2 CV_{it} + \varepsilon_{it} \quad (3.6)$$

where y is per capita GDP; A is the volume of foreign aid; FD is an indicator of financial development; TD is a vector of time dummies proxying for the impact of civil wars; and CV is a vector of typical control variables such as the initial income level, inflation, government expenditure, human capital investment, rule of law and trade openness. Notably, all variables were measured as the average of five-year non-overlapping periods. The system GMM estimator was used, and the empirical result indicated a linear relationship between the RER misalignment and economic growth. It was found that overvaluation could hinder growth and this negative effect is intensified by the interaction with aid but is weakened by the interaction with financial development. This finding is in line with Philippe Aghion, Bacchetta, Rancière, and Rogoff (2009) who discovered that the effect of real devaluation on productivity depends on the level of financial development.

Johnson, Ostry, and Subramanian (2010) applied a benchmarking approach to investigate the effect of overvaluation on economic growth in 50 African countries. They selected 12 developing countries that had achieved sustained growth as benchmarking countries. Following Prasad et al. (2007), they employed a cross-section regression to estimate a RER misalignment index. Subsequently, they calculated the African countries' 5-year averages of the RER misalignment index in the last periods for which data are available, and compared these to the benchmarking countries' averages of the RER misalignment index in their high-growth episodes. It was shown that most of the benchmarking countries did not suffer overvaluation in their high-growth periods. In contrast, the currencies of 19 African countries that experienced growth rate more than 2% were 7% overvalued, and the currencies of 31 African countries with growth rate less than 2% were 18% overvalued.

R. G. Rajan and Subramanian (2011) conjectured that overvaluation could affect negatively the profitability of manufacturing industries. They sampled 3-digit manufacturing industries in developing countries over the period from the 1980s to 1990s. They applied the framework advanced by Prasad et al. (2007) to measure the RER misalignment. Results of OLS estimation with country and industry fixed effects demonstrated the negative (positive) effect of overvaluation (undervaluation) on manufacturing industries' value added.

Gluzmann, Levy-Yeyati, and Sturzenegger (2012) questioned Rodrik (2008)'s hypothesis that the RER influences economic growth through the tradable sector channel. They replicated Rodrik (2008)'s empirical analysis framework with updated data. Similar to Rodrik (2008), they found that the effect of undervaluation (overvaluation) on growth is statistically significant and positive (negative) in developing countries but not significant in developed countries. Further, Gluzmann et al. (2012) examined the influence of undervaluation to sources of economic growth in developing countries. In contrast to Rodrik (2008)'s prediction, the empirical result provided little evidence to support the role of undervaluation in promoting the tradables sector. Instead, it was found that investment, saving and employment are more likely the channels through which undervaluation affects economic growth.

Ndhlela (2012) investigated the effect of RER misalignment on economic growth in Zimbabwe, using monthly data over the period 1985-2004[13]. Following Edwards (1995a), an RER misalignment index was derived from the reduced-equation approach. A growth model was then specified in which real GDP growth was a function of the RER, the RER misalignment, the RER volatility and control variables such as gross capital formation and time dummies. The bound testing approach developed by Pesaran and Smith (1998) and Pesaran, Shin, and Smith (2001) was applied and empirical results lent support to the existence of a long-run relationship among the variables. Consequently, an ARDL model could be estimated to capture both short- and long-run relationships among variables. Ndhlela (2012) concluded that there is a significant and positive (negative) relationship between undervaluation (overvaluation) and economic growth in Zimbabwe.

Alper and Civcir (2012) employed the behaviour equilibrium real exchange rate (BEER) approach developed by Faruqee (1995) and extended by Alberola Ila, Garcia Cervero, Lopez, and Ubide (1999) to estimate the RER misalignment of the Turkish lira over the period 1987Q1:2010Q4. In essence, Alper and Civcir (2012) compared the correspondence between the misalignments of the Turkish lira and economic growth rates. Overvaluation was considered as large and persistent if the RER misalignment index indicated that the Turkish

[13] Monthly data on GDP are provided by the Reserve Bank of Zimbabwe. Statistic data on GDP are often collected on quarterly basic or lower frequencies. High-frequency output data are hardly used in empirical analyses due to a large noise to signal ratio.

lira was overvalued by more than 7% on average for a period of at least three continuous years. They found that although large and persistent overvaluation appears to be a warning signal of a potential crisis, moderate overvaluation could surprisingly promote economic growth. This was explained as moderate overvaluation tends to lower the costs of imported capital and thereby stimulate investment and economic growth. Particularly, this finding is in contrast to both the Washington consensus view and mercantilist's perspectives. However, it should be noted that because Alper and Civcir (2012) did not take into account the lagged effects of the RER misalignment as well as the impact of other growth determinants, the statistical correlation between moderate overvaluation and economic growth could be misleading. This is because the high performance of the Turkish economy during the moderate overvalued periods might have originated from the lagged effect of previous undervalued periods or the innovation of other economic factors such as investment, labour and technology.

Based on the reduced-equation approach, Vieira and MacDonald (2012) estimated the RER misalignment for 90 countries over the period 1980-2004. They considered four ERER determinants, namely per capita income, net foreign asset, the terms of trade and government expenditure consumption, and then specified seven different combinations of them to establish alternative ERER determinant models. Subsequently, a growth model was specified in which the RER misalignment, education attainment, institutional factors, government consumption, and inflation were explanatory variables. They applied the system GMM estimator and found consistent evidence across regressions using alternative RER misalignment indices. The empirical result indicates that undervaluation could foster economic growth while overvaluation could hinder economic growth. Moreover, the correlation between the RER misalignment and economic growth was found to be stronger in developing and emerging countries.

Razmi et al. (2012) argued that undervaluation could support economic growth by stimulating the capital accumulation process. The operation of this channel could be especially robust in developing countries where there is plenty of unemployed labour and the capital is mostly imported. Seeking empirical evidence to support the relationship between undervaluation and investment growth, they examined a panel consisting of 153 countries and nine 5-year periods from 1960 to 2004. An RER misalignment index was estimated by Rodrik (2008)'s procedure. Based on two-step GMM and OLS estimators, the growth of investment was regressed on the RER misalignment and a set of control variables, namely government consumption, openness, education level, the terms of trade and institutional factors. The empirical result demonstrated a positive (negative) and significant relationship between undervaluation (overvaluation) and investment growth. Moreover, it was proved that this relationship is more significant in developing countries than developed countries.

Using time series techniques, Wong (2013) examined the relationship between the RER misalignment and economic growth in Malaysia over the period 1971-2008. The reduced-equation approach was applied to estimate the RER misalignment. An ERER determinant model was specified using conventional explanatory variables such as the real interest rate, productivity, international reserves, the oil price, and time dummies. The relationship between the RER misalignment and economic growth was then examined through a growth model in which economic growth is a function of the RER misalignment, the number of labour, capital stock, the terms of trade and time dummies. The bound testing approach (Pesaran et al., 2001; Pesaran & Smith, 1998) was employed to investigate the long-run relationship between variables in the growth models. Since the result of the bound testing approach supported the cointegration between variables, an unrestricted error correction model (ECM) could be estimated and its coefficients indicated a positive (negative) long-run relationship between undervaluation (overvaluation) and economic growth.

Bereau et al. (2012) argued that the correlation between the RER misalignment and economic growth could be nonlinear in nature. They employed the panel smooth transition regression (PSTR) method advanced by Gonzalez, Terasvirta, and Dijk (2005) to investigate the existence of a nonlinear relationship between the RER misalignment and economic growth. Bereau et al. (2012) looked at a sample comprising annual observations in both developing and industrial countries over the period 1980-2007. Based on the BEER approach to estimate the RER misalignment, an ERER equation was specified in which the determinants of the ERER were net foreign asset position, the terms of trade and the relative productivity of the traded sector to the non-traded sector. Results from the Pedroni panel cointegration test (Pedroni, 1999, 2004) revealed that the actual RER and its determinants are cointegrated. The pooled mean group (PMG) procedure proposed by Pesaran, Shin, and Smith (1999) was then employed to estimate the cointegration vector.

Having estimated an RER misalignment index, Bereau et al. (2012) specified a growth model of which the regressors were the RER misalignment, inflation, investment, trade openness, population growth and the initial GDP level. The PSTR regression result indicated that the RER misalignment has a threshold level of 2.4%. This confirms the hypothesis of the nonlinear correlation between the RER misalignment and economic growth. The regression result shows that the coefficient of the RER misalignment monotonically decreases as the RER misalignment increases toward overvaluation. This means that extreme levels of both overvaluation and devaluation could be harmful to economic growth [14]. In order to conduct robustness checks, Bereau, Villavicencio, and Mignon (2012) made use of two alternative measures of the RER misalignment which were the deviation of the actual RER from its trend values derived by the Hodrick–Prescott filter method, and the PPP-based measure. The empirical evidence appears to be consistent across regressions using different measures of the RER misalignment. Moreover, the difference GMM estimator was applied in order to confirm the nonlinearity of the relationship between the RER misalignment and economic growth. The coefficient of the RER misalignment in the GMM model is negative and statistically significant. This means that overvaluation and undervaluation tend to have opposite effects on economic growth. While overvaluation influences economic growth negatively, undervaluation supports economic growth. Overall, the empirical results from both nonlinear and linear regressions seem

[14] Surprisingly, Bereau et al. (2012) seemed to misinterpret the empirical result as they claimed a positive relationship between growth and undervaluation and a positive relationship between growth and overvaluations.

to demonstrate that both undervaluation and overvaluation hamper economic growth but undervaluation is less destructive than overvaluation.

Mbaye (2012) conjectured that total factor productivity (TFP) could be a main transmission channel through which the RER misalignment influences growth. In seeking empirical evidence, he examined an econometric model of TFP growth using a dataset comprising 72 countries over the period 1970-2008:

$$TFPG_{it} = \alpha + \beta_1 TFPG_{i(t-1)} + \beta_2 RERMIS_{it} + \beta_3 Z_{it} + \varepsilon_{it} \quad (3.7)$$

where $TFPG$ is the TFP growth rate derived from the growth accounting framework; $RERMIS$ is the RER misalignment; and Z is a set of TFP growth determinants including human capital, trade openness, financial development, institutional factors, and the investment to GDP ratio. The RER misalignment index was estimated by a framework similar to one developed by Rodrik (2008). The GMM regression showed significant evidence for the positive effect of undervaluation on TFP growth. Subsequently, following Aguirre and Calderon (2005), Mbaye (2012) split the RER misalignment to construct separate overvaluation and undervaluation variables to inspect the nonlinear effect of RER misalignment on TFP. The estimation result confirmed the role of undervaluation in enhancing TFP growth and suggested, surprisingly, that overvaluation could have moderately positive influence on TFP growth.

Nouira and Sekkat (2012) contributed to the debate on the causal effect of undervaluation on economic growth by focusing on the econometric and empirical issues. Due to the endogeneity of undervaluation in growth models, they cast doubt on the validity of documented empirical evidences on the positive effect of undervaluation on economic growth. Firstly, based on the BEER approach, the RER misalignment was estimated in 52 developing countries in Africa, Asia and Latin America over the period 1980–2005[15]. Subsequently, a growth model in which the growth rate of per capita GDP was a function of the RER misalignment, the initial level of per capita GDP, investment, school enrolment and population was investigated by three estimation different methods: fixed-effect OLS using 5-year non-overlapping

[15] Details of the BEER method are provided in Chapter 2.

observations, GMM using 5-year non-overlapping observations, and panel cointegration using yearly observations [16]. Since results of the panel cointegration test proposed by Pedroni (2004) indicated that variables are cointegrated, the dynamic OLS method developed by Kao and Chiang (2000) was used to estimate coefficients of long-run cointegration vectors. The effect of the RER misalignment on economic growth is significant in OLS regression but is insignificant with the other estimations. Following Aguirre and Calderon (2005), Nouira and Sekkat (2012) split the RER misalignment index into two separate series: undervaluation and overvaluation for robustness testing purposes. Undervaluation and overvaluation variables were then used in replace of the RER misalignment in the growth model. Empirical evidence does not indicate a significant effect of undervaluation but they are consistently supporting that overvaluation is harmful to economic growth. In another robustness analysis, similar to Alper and Civcir (2012), Nouira and Sekkat (2012) employed the notion of persistent undervaluation and persistent overvaluation. The persistent undervaluation (overvaluation) equals a 5-year average of the undervaluation (overvaluation) variable if the RER is always undervalued (overvalued) during this 5-year period; or equals 0 otherwise. Overall, there is evidence supporting the negative effect of persistent overvaluation on economic growth while the effect of persistent overvaluation is not consistent across regressions using different estimation methods and model specifications. Finally, following Razin and Collins (1999), Nouira and Sekkat (2012) subdivided undervaluation and undervaluation into low, medium and high categories to inspect the nonlinear relationship between the RER misalignment and economic growth. Again, no support for the nonliner relationship was found.

Similar to Nouira and Sekkat (2012), Schroder (2013) attempted to probe the validaty of empirical evidence on the positive effect of undervaluation on economic growth documented in the literature. However, while Nouira and Sekkat (2012) focused on addressing the endogeneity issue, Schroder (2013) inspected the impact of inappropirate homogeneity assumptions on empirical

[16] Nouira and Sekkat (2012) did not mention whether difference or system GMM estimator was used.

results. Schroder (2013) argued that previous studies tended to commit two inconsistencies. First, they often employed panel data techniques to derive a single equation that was then used to estimate the ERER for every countries in the panel. This assumed homegeneity could be inconsistent with theoretical ground, which suggests that the impact of fundamental factors on ERER might not be the same or even opposite in different countries. To address this problem, Schroder (2013) recommended estimating separate equations for each country. Second, the conventional method to avarage the RER misalignment series over 5-year overlapping periods could lead to model misspecification if undervaluation and overvaluation do not have equal but opposite sign effects on economic growth. Schroder (2013) proposed spliting the RER misalignment series into overvaluation and undervaluation variables before averaging across periods. Notably, while an index estimated by Schroder (2013)'s method could better measure the fluctuation of a country's RER misalignment over time, it does not provide accurate inter-country comparison. In detail, since the RER misalignment is indexed by residuals of a ERER model regression, the sum of the RER misalignment index of a country for a whole time-sample tends to equal 0. For example, even if a country's RER is overvalued for the whole estimated period, its RER misalignment index could receive both positive and negative signs in this period.

Following the BEER model developed by Faruqee (1995), Schroder (2013) estimated the RER misalignment in 63 individual countries over the period 1970-2007. Subsequently, a growth model was investigated in which economic growth was a function of undervaluation, overvaluation, initial income, investment, technology progress, the terms of trade, trade openness, government consumption, net foreign asset possition, human capital, and rules of law. Results of OLS and system GMM regressions support the Washinton consensus viewpoint that both undervaluation and overvaluation harm economic growth. This conclusion was then confirmed by an episode analysis. Finally, Schroder (2013) duplicated the Rodrik (2008)'s studies and introduced slope dummies into the ERER equation to account for parameter heterogeneity. It was shown that the Rodrik (2008)'s results do not stand up to scrutiny.

Table 3.1 presents a summary of selected empirical studies on the relationship between the RER misalignment and economic growth. It summarises the samples and estimation techniques used in these studies as well as evidences documented on growth effect of the RER misalignment.

Table 3.1: Selective empirical studies on the causality between the RER misalignment and economic growth

Study	Sample	Estimation techniques	Effect on economic growth
Cottani et al. (1990)	24 developing countries Period: 1960-83	OLS	Undervaluation: positive Overvaluation: negative
Dollar (1992)	95 developing countries Period: 1976 – 1985	OLS	Undervaluation: positive Overvaluation: negative
Ghura and Grennes (1993)	33 SSA countries Period: 1972– 1987	IV	Undervaluation: positive Overvaluation: negative
Razin and Collins (1999)	93 countries Period 1975-1983 and 1984-1992	OLS	High (not very high) devaluation: positive Very high overvaluation: negative Others: not significant
Shabsigh and Domac (1999)	Egypt, Jordan, Morocco and Tunisia Period:1970-1995	3SLS	Undervaluation: positive Overvaluation: negative
Bleaney and Greenaway (2001)	14 Sub-Saharan countries Period: 1980-1995	IV Fixed-effect OLS	Undervaluation: positive Overvaluation: negative
Acemoglu et al. (2003)	73 ex-colony countries Period: 1970-1997	2SLS	Overvaluation: negative
Aguirre and Calderon (2005)	60 countries Period: 1965-2003	System GMM	Undervaluation: negative Overvaluation: negative
Hausmann et al. (2005)	83 episodes of rapid growth acceleration	Correlation analysis	Undervaluation: positive
Gala and Lucinda (2006)	58 developing countries 1960-1999	Pooled OLS Fixed-effect OLS Difference GMM System GMM	Not significant

Study	Sample	Estimation techniques	Effect on economic growth
Bhalla (2007)	Except oil exporting or less than 1 million population countries Period: 1980-2006	OLS Fixed-effect OLS Difference GMM	Undervaluation: positive Overvaluation: negative
Prasad et al. (2007)	59 developing countries Period: 1970-2004	Pooled OLS Difference GMM System GMM	Undervaluation: positive Overvaluation: negative
Gala (2008)	50 developing countries Period: 1960-1999	Difference GMM System GMM	Undervaluation: positive Overvaluation: negative
Rodrik (2008)	188 countries Period: 1950-2004	Difference GMM System GMM	Undervaluation: positive Overvaluation: negative Not significant in industrial countries
Elbadawi et al. (2008)	39 conflict and 44 non-conflict developing country Period: 1970-2004	System GMM	Undervaluation: positive Overvaluation: negative
Johnson et al. (2010)	50 African countries and 12 benchmarking countries Period: 1970 -2000	Benchmarking approach	Overvaluation: negative
Rajan and Subramanian (2011)	3-digit manufacturing industries in developing countries Period: 1980s to 1990s	OLS	Undervaluation: positive Overvaluation: negative
Ibarra (2011)	Mexico quarterly data from 1988 to 2006	ECM	Overvaluation reduce investment
Gluzmann et al. (2012)	Rodrik (2008)'s updated sample	OLS	Undervaluation: positive Overvaluation: negative Not significant in industrial countries
Ndhlela (2012)	Zimbabwe Period: 1985-2004	ARDL	Undervaluation: positive Overvaluation: negative
Alper and Civcir (2012)	Turkey Period: 1987-2010	Correlation analysis	High overvaluation: negative Low overvaluation: positive
Vieira and MacDonald (2012)	90 countries Period: 1980-2004	System GMM	Undervaluation: positive Overvaluation: negative

Study	Sample	Estimation techniques	Effect on economic growth
Rapetti et al. (2012)	Rodrik (2008) dataset	System GMM OLS	Undervaluation: positive Overvaluation: negative Not significant in middle income countries
Bereau et al. (2012)	30 countries and Eurozone Period: 1980-2007	PSTR	Undervaluation: negative Overvaluation: negative Undervaluation is less destructive than overvaluation
Mbaye (2012)	72 countries Periods: 1970-2008	Difference GMM System GMM	Undervaluation: positive Overvaluation: positive
Nouira and Sekkat (2012)	52 developing countries Periods: 1980-2005	Fixed-effect OLS GMM; DOLS	Not significant
Wong (2013)	Malaysia Period: 1971-2008	ARDL	Undervaluation: positive Overvaluation: negative
Schroder (2013)	63 individual countries Period: 1970-2007	OLS System GMM	Undervaluation: negative Overvaluation: negative

Source*: The author*

3.4 Summary

The relationship between the RER misalignment and economic growth has drawn much attention for more than last two decades, perhaps partly because of its important policy implications. This is reflected in the large and increasing number of studies focusing on seeking empirical evidence of this relationship as summarized in Table 3.1. Since the negative effect of overvaluation on economic growth is obvious, both theoretical and empirical studies focus on the controversial role of undervaluation.

There are two dominant views arguing for the growth-enhancing effect of undervaluation. The first view emphasises the externalities of a competitive exchange rate (e.g Rodrik, 2008). The second view advocates the role of an undervalued RER in releasing a country's balance of payments constraint (e.g Gala, 2008; Porcile & Lima, 2010). However, in general, the theoretical research exploring the role of the RER misalignment on economic growth is merely at the beginning stage (P. Montiel & Serven, 2008). The channels through which the RER misalignment influences economic growth have not been sufficiently explored (Nouira & Sekkat, 2012).

Evidence of the positive effect of undervaluation on economic growth has dominated the empirical literature. Nevertheless, recent studies that thoroughly investigate the validity of conventional empirical strategies in estimating the correlation between the RER misalignment and economic growth have raised questions on the robustness of the documented evidence. Noticeably, the statistical correlation between RER misalignment and economic growth could be exaggerated because of the equation-based framework used to estimate the RER (Henry & Woodford, 2008). Moreover, Nouira and Sekkat (2012) showed that the relationship between the RER misalignment and economic growth turns out to be insignificant after addressing the endogeneity issue. The impact of undervaluation on economic growth was reported to be negative in the study of Schroder (2013) who corrected the heterogeneity and the misleading averaging issues in constructing an undervaluation index.

CHAPTER 4

A THEORETICAL MODEL ON THE EFFECT OF REAL EXCHANGE RATE DEPRECIATION ON CAPITAL ACCUMULATION

4.1 Introduction

The real exchange rate (RER) received little attention from economic growth theorists until recently, despite the importance of a competitive exchange rate prompted in Lewis's theory of economic growth (Lewis, 1954) which emphasises the reallocation process by which labour in the rural areas is redeployed in the modern manufacturing sector in developing countries. This is perhaps because the neoclassical approach considers the exchange rate as an endogenous variable which equilibrates external and internal balances, thereby assigning it a subsidiary and minor role in the process of growth. Indeed, a class of neoclassical growth models, starting with R. Solow (1957) and Rostow (1960), feature closed-economies and hence give RERs no prominence. However, the numbers of adherents who argue for a more important role for RER targeting have been bolstered by the observed success of export-led growth strategies in developing countries, where policies which target a competitive exchange rate are an essential component (Bereau et al., 2012; Hausmann et al., 2005; Prasad et al., 2007; Rodrik, 2008).

Despite a growing consensus among policy makers about the importance of a competitive exchange rate, theoretical understanding remains limited concerning the mechanism through which the growth-effects of RERs are generated. Conjectures focus mainly on the productivity (Eichengreen, 2007; Rodrik, 2008) and the capital accumulation channels (Gala, 2008; P. Montiel & Serven, 2008; Porcile & Lima, 2010; Razmi et al., 2012). This chapter offers a theoretical model to explore the influence of depreciation of the RER through the capital accumulation channel.

The effect of nominal devaluation on investment has been long analysed in open economy models (e.g. Buffie, 1986; Buffie & Won, 2001; Chang & Tsai, 2006). By contrast, few studies have examined the impact of an RER movement. Rodrik (2008) carried out pioneer research focusing on static equilibrium in a small and open economy and analysed the role of the RER in attaining an optimal economic configuration. At the forefront of this literature, the capital accumulation channel is carried out in the context of Keynesian economics (e.g. Gala, 2008; Porcile & Lima, 2010). Gala (2008) showed that a depreciated RER could lead to lower real wages and a higher profit margin in firms, thus promoting investment. Porcile and Lima (2010) developed a well-known growth model with a balance of payments constraint and showed in the model that since excess demand for imported capital always exists, the investment schedule depends solely on the behaviour of exports and hence the RER. As the role of capital inflow was excluded, their argument was straightforward that depreciation in the RER could stimulate exports and increase the supply of foreign exchange for imported capital goods. While the Gala study focused merely on short-run effects, the channel analysed by Porcile and Lima refers to longer-term effects, although still was restricted by an assumption of the balance of payments constraint.

The investment enhancing effect of undervaluation is analysed by Razmi *et al*. (2012). They modelled the interaction between RER depreciation and investment in an open economy under the assumptions of unemployment and constant returns to scale. However, their study did not conduct a rigorous intertemporal analysis based on optimising behaviours and failed to depict the effect of RER depreciation by allowing the RER to be an endogenous variable in the steady state.

In contrast, the theoretical model in this chapter concentrates on the effect of a depreciation in the RER within a well specified dynamic system. It analyses the role of the RER along the growth process instead of focusing exclusively on a steady state economy. The analysis better fits the circumstances of developing countries which are hardly considered as to be in the vicinity of the steady state. Moreover, this model relies on the typical assumptions of neoclassical economics distinguishing it from previous studies (Gala, 2008; Porcile & Lima, 2010) which were developed in a Keynesian framework.

4.2 The model

4.2.1 The production function

The model considers a small and open economy consisting of two sectors producing tradable and non-tradable goods. Tradable goods are produced by capital K and labour L while the non-tradables are produced solely by the labour input. The quantity of labour in the economy is constant and there is full employment. Non-tradables are produced using a constant returns to scale technology. The tradable sector is assumed to have an increasing concave production function with imperfect substitution between inputs. The economy is small, hence can sell as much of the tradable good at a fixed foreign price as it can produce.

$$Q_t^T = Q(K_t, L_t^T);\ K_t > 0,\ L_t^T > 0 \tag{4.1}$$

$$Q_t^N = wL_t^N;\ w > 0 \tag{4.2}$$

where Q^T and Q^N denote output of tradable and non-tradable sectors, respectively. $L^T$and L^N denote the quantities of labour in the tradable and non-tradable sectors, and $L^T + L^N = L.t$ is the time subscript.

Assuming perfect labour mobility, labour unit costs are equal between the tradable and non-tradable sectors.

$$w = \frac{\delta Q(K_t, L_t^T)}{\delta L_t^T} e;\ e > 0 \tag{4.3}$$

where e denotes the RER which is the relative price of tradable goods to non-tradable goods. Because w is constant, the quantity of labour used in the tradable sector is determined by the stock of capital and RER, that is, $L_t^T = f(K_t, e)$.

4.2.2 The optimisation problem

It is assumed that the capital good is not domestically produced, and that a representative firm in the tradable sector, with perfect foresight, maximises its intertemporal profit after investing in the imported capital good and paying its labour costs. The representative firm's optimisation problem is to find the path for investment (I) that maximises total discounted profit over an infinite horizon:

$$max \int_0^\infty \left(eQ(K_t, L_t^T) - wL_t^T - eC(I_t)\right) \exp(-\vartheta t)\, dt \tag{4.4}$$

Subject to:

$$\dot{K}_t = I_t - \varphi K_t;\ I_t > 0 \tag{4.5}$$

$$K_0 = \overline{K} \tag{4.6}$$

where $C(I_t)$ is the investment cost function which is assumed to be increasing and strictly convex, $C'\left((I_t)\right) > 0$ and $C''\left((I_t)\right) > 0$. It should be noted that this assumption is standard in the neoclassical theory of investment as it prevents swift changes in variables, thereby ensuring variables gradually evolving over time. ϑ denotes a subjective discount rate which depends on the world real interest rate and is assumed to be constant over time. φ denotes the depreciation rate of capital goods, $\varphi > 0$. A dot over a variable signifies a time derivative. K_t is continuously differentiable on (0, ∞). To simplify notation, the subscript t is dropped for the remainder of this chapter.

The current-value Hamiltonian for the problem is formed as below:

$$H = \left(eQ(K, L^T) - wL^T - eC(I)\right) + \lambda(I - \varphi K) \tag{4.7}$$

The necessary conditions for the optimisation are:

$$\frac{\partial H}{\partial I} = \lambda - e\frac{\partial C(I)}{\partial I} = 0 \tag{4.8}$$

$$\dot{\lambda} = \vartheta\lambda - \frac{\partial H}{\partial K}$$

$$= \vartheta\lambda - \left(e\frac{\partial Q(K, L^T)}{\partial K} + e\frac{\partial Q(K, L^T)}{\partial L^T}\frac{dL^T}{dK} - w\frac{dL^T}{dK}\right) + \varphi\lambda$$

$$= (\vartheta + \varphi)\lambda - e\frac{\partial Q(K, L^T)}{\partial K} \tag{4.9}$$

Transforming Equation (4.8) and differentiating both sides:

$$\lambda = e\frac{\partial C(I)}{\partial I} \tag{4.10}$$

$$\dot{\lambda} = e\frac{\partial^2 C(I, K)}{\partial I^2}\dot{I} \tag{4.11}$$

Substituting Equations (4.10) and (4.11) into Equation (4.9)

$$e\frac{\partial^2 C(I)}{\partial I^2}\dot{I} = (\varphi + \vartheta)e\frac{\partial C(I)}{\partial I} - e\frac{\partial Q(K, L_T)}{\partial K} \tag{4.12}$$

$$\Leftrightarrow \quad \frac{\partial^2 C(I)}{\partial I^2}\dot{I} = \frac{\partial C(I)}{\partial I}(\varphi + \vartheta) - \frac{\partial Q(K, L_T)}{\partial K} \tag{4.13}$$

$$\Leftrightarrow \quad \dot{I} = \left(\frac{\partial C(I)}{\partial I}(\vartheta + \varphi) - \frac{\partial Q(K, L_T)}{\partial K}\right) \bigg/ \frac{\partial^2 C(I)}{\partial I^2} \tag{4.14}$$

Conditions (4.5), (4.6) and (4.14) define a class of feasible paths to the optimisation problem. However, because there is only one initial condition, $K_0 = \bar{K}$, and the initial values of control variable, I_0 is endogenously determined, an additional necessary condition is required to solve for the optimal path. In finite-horizon dynamic optimisation problems, transversality conditions can be employed to determine optimal solutions, but transversality conditions are only obtained by strict restrictions in infinite-horizon problems (Leonard & Long, 1992, p. 288). Attention is naturally drawn to the feasible path leading to the steady state which is sufficient to be an optimal path if the Hamiltonian function Equation (4.7) is concave in (I, K).

The concavity of the Hamiltonian function (4.7) is difficult to examine directly without specifying a form for the production function $Q(K, L^T)$, and investment cost function $C(I)$, which would allow an explicit solution to be derived. Nevertheless, when the costate variable has a definite sign, the concavity of the Hamiltonian function (4.7) can be ascertained (Leonard, 1981).

Lemma 1: *The Hamiltonian function (*4.7) *is concave in* (I, K)

Proof: As proved by Leonard (1981), the Hamiltonian function (4.7) is concave in (I, K) if the following conditions are satisfied:

(i) $v(I, K) = \left(eQ(K, L^T) - wL^T - eC(I)\right)\exp(-\vartheta t)$ is concave in (I, K)

(ii) $f = (I - \varphi K)$ is concave in (I, K)

(iii) $\mu \geq 0$

To examine the concavity of $v(I, K)$, the Hessian matrix of $D^2 v$ is investigated.

From the first partial derivatives of $v(I, K)$ with respect to K

$$\frac{\partial v}{\partial K} = e\frac{\partial Q(K, L^T)}{\partial K} + e\frac{\partial Q(K, L^T)}{\partial L^T}\frac{\partial L^T}{\partial K} - w\frac{\partial L^T}{\partial K}$$

$$= e\frac{\partial Q(K, L^T)}{\partial K} \tag{4.15}$$

then

$$\frac{\partial^2 v}{\partial K^2} = e\left(\frac{\partial^2 Q(K, L^T)}{\partial K^2} + \frac{\partial^2 Q(K, L^T)}{\partial K \partial L^T}\frac{\partial L^T}{\partial K}\right) < 0 \tag{4.16}$$

From Equation (4.3):

$$\frac{\partial Q(K, L^T)}{\partial L^T} = \frac{w}{e} \tag{4.17}$$

$$\Rightarrow \quad \frac{\partial^2 Q(K, L^T)}{\partial L^{T^2}} dL^T + \frac{\partial^2 Q(K, L^T)}{\partial L^T \partial K} dK = 0 \tag{4.18}$$

$$\Rightarrow \quad \frac{dL^T}{dK} = -\frac{\frac{\partial^2 Q(K, L^T)}{\partial K \partial L^T}}{\frac{\partial^2 Q(K, L^T)}{\partial L^{T^2}}} \tag{4.19}$$

Substitute Equation (4.19) into Equation (4.16):

$$\frac{\partial^2 v}{\partial K^2} = e\left(\frac{\partial^2 Q(K, L_T)}{\partial K^2} - \frac{\left(\frac{\partial^2 Q(K, L^T)}{\partial K \partial L^T}\right)^2}{\frac{\partial^2 Q(K, L^T)}{\partial L^{T^2}}}\right) \tag{4.20}$$

Because $Q(K, L^T)$ is a concave function

$$\frac{\partial^2 Q(K, L^T)}{\partial K^2}\frac{\partial^2 Q(K, L^T)}{\partial L^{T^2}} - \left(\frac{\partial^2 Q}{\partial K \partial L^T}\right)^2 \geq 0 \tag{4.21}$$

$$\frac{\partial^2 Q(K, L^T)}{\partial L^{T^2}} \leq 0 \tag{4.22}$$

Combining Equations (4.22) and (4.21)

$$\frac{\partial^2 Q(K,L^T)}{\partial K^2} - \frac{\left(\frac{\partial^2 Q(K,L^T)}{\partial K \partial L^T}\right)^2}{\frac{\partial^2 Q(K,L^T)}{\partial {L^T}^2}} \leq 0 \tag{4.23}$$

$$\Rightarrow \quad \frac{\partial^2 v}{\partial K^2} \leq 0 \tag{4.24}$$

Moreover, considering the second-order partial derivatives with respect to I and the mixpartial derivatives:

$$\frac{\partial^2 v}{\partial I^2} = -e\frac{\partial^2 C(I)}{\partial^2 I} < 0 \tag{4.25}$$

$$\frac{\partial^2 v}{\partial I \partial K} = 0 \tag{4.26}$$

Combining Equations (4.24), (4.25) and (4.26) and deriving the Hessian matrix:

$$H_2(v) = \exp(-\vartheta t)\begin{pmatrix} e\left(\frac{\partial^2 Q(K,L^T)}{\partial K^2}\right) & 0 \\ 0 & -e\frac{\partial^2 C(I)}{\partial^2 I} \end{pmatrix} \tag{4.27}$$

Because the principal minors of $H_2(v)$ are negative ($M_1 = e\frac{\partial^2 Q(K,L^T)}{\partial K^2}$; $M_1' = -e\frac{\partial^2 C(I)}{\partial^2 I}$), and the only second order principal minor is positive ($M_2 = -e^2\frac{\partial^2 Q(K,L^T)}{\partial K^2}\frac{\partial^2 C(I)}{\partial^2 I}$), $H_2(v)$ is a positive semi-definite matrix. $v(K,I)$ is, therefore, concave in (I,K). Condition (i) is satisfied.

In addition, f is a linear function of I and K, hence it is concave in (I,K). Therefore, condition (ii) is satisfied.

Finally, condition (iii) is satisfied since by Equation (4.10):

$$\lambda = e\frac{\partial C(I)}{\partial I} > 0 \tag{4.28}$$

Because the conditions (i), (ii), and (iii) are satisfied, Lemma 1 is proved.

As noted, provided that the Hamiltonian function (4.7) is concave in (I, K), the sufficiency condition implies that the feasible path leading to the steady state is an optimal path.

Proposition 1: *Provided that the Hamiltonian function (*4.7) *is concave in* (I, K)*, a feasible path* (I^m, K^m) *converges to the steady state and satisfies the sufficient condition to be an optimal path*[17]

$$\lim_{t\to\infty}\left(\frac{\lambda^m}{\exp(\vartheta t)}(K^f - K^m)\right) \geq 0 \tag{4.29}$$

where K^f is any feasible path.

Proof: Since with any feasible path, $K_t > 0\ \forall t$, $(K^f - \mathrm{K}^*)$ is bounded:

$$\lim_{t\to\infty}(K^f - K^m) = \lim_{t\to\infty}(K^f - \mathrm{K}^*) > -K^* \tag{4.30}$$

Substitute Equation (4.10) into Equation (4.29) and combine with Equation (4.30)

$$\lim_{t\to\infty}\left(\frac{\lambda^m}{\exp(\vartheta t)}(K^f - K^m)\right) = \lim_{t\to\infty}\left(e\frac{1}{\exp(\vartheta t)}\frac{\partial C(I^m)}{\partial I^m}(K^f - K^m)\right) \tag{4.31}$$

[17] Further details of the sufficiency conditions for optimality, see Leonard and Long (1992, p. 288))

$$\Rightarrow \quad \lim_{t\to\infty}\left(\frac{\lambda^*}{\exp(\vartheta t)}(K^f - K^m)\right) > \left(-eK^*\frac{\partial C(I^*)}{\partial I^*}\right)\lim_{t\to\infty}\left(\frac{1}{\exp(\vartheta t)}\right) \tag{4.32}$$

$$\Rightarrow \quad \lim_{t\to\infty}\left(\frac{\lambda^*}{\exp(\vartheta t)}(K^f - K^m)\right) > 0 \tag{4.33}$$

The Proposition 1 is proved.

4.2.3 A phase analysis

Denote

$$\Gamma(I,K) \equiv \frac{\partial C(I)}{\partial I}(\vartheta + \varphi) - \frac{\partial Q(K,L^T)}{\partial K} \tag{4.34}$$

Consider the locus of $\dot{I} = 0$, from Equation (4.14):

$$\Gamma(I,K) = 0 \tag{4.35}$$

$$\Rightarrow \quad \frac{\partial \Gamma(I,K)}{\partial I}\Delta I + \frac{\partial \Gamma(I,K)}{\partial K}\Delta K = 0 \tag{4.36}$$

$$\Rightarrow \quad \left.\frac{dI}{dK}\right|_{\dot{I}=0} = -\frac{\partial \Gamma(I,K)}{\partial K} \Big/ \frac{\partial \Gamma(I,K)}{\partial I} \tag{4.37}$$

Examining separately the signs of the right-hand side components in Equation (4.37)

$$\frac{\partial \Gamma(I,K)}{\partial I} = \frac{\partial^2 C(I)}{\partial I^2}(\vartheta + \varphi) > 0 \tag{4.38}$$

$$\frac{\partial \Gamma(I,K)}{\partial K} = -\left(\frac{\partial^2 Q(K,L_T)}{\partial K^2} + \frac{\partial^2 Q(K,L^T)}{\partial K \partial L}\frac{dL^T}{dK}\right) \tag{4.39}$$

Substitute Equation (4.19) into Equation (4.39):

$$\frac{\partial \Gamma(I,K)}{\partial K} = -\left(\frac{\partial^2 Q(K,L_T)}{\partial K^2} - \frac{\left(\frac{\partial^2 Q(K,L^T)}{\partial K \partial L^T}\right)^2}{\frac{\partial^2 Q(K,L^T)}{\partial {L^T}^2}} \right) \tag{4.40}$$

From Equation (4.23), it can be shown that

$$\frac{\partial \Gamma(I,K)}{\partial K} > 0 \tag{4.41}$$

Finally, combine Equation (4.41) with Equation (4.38), and substitute into Equation (4.37)

$$\left.\frac{dI}{dK}\right|_{\dot{I}=0} \leq 0 \tag{4.42}$$

Figure 4.1: Saddle path diagram

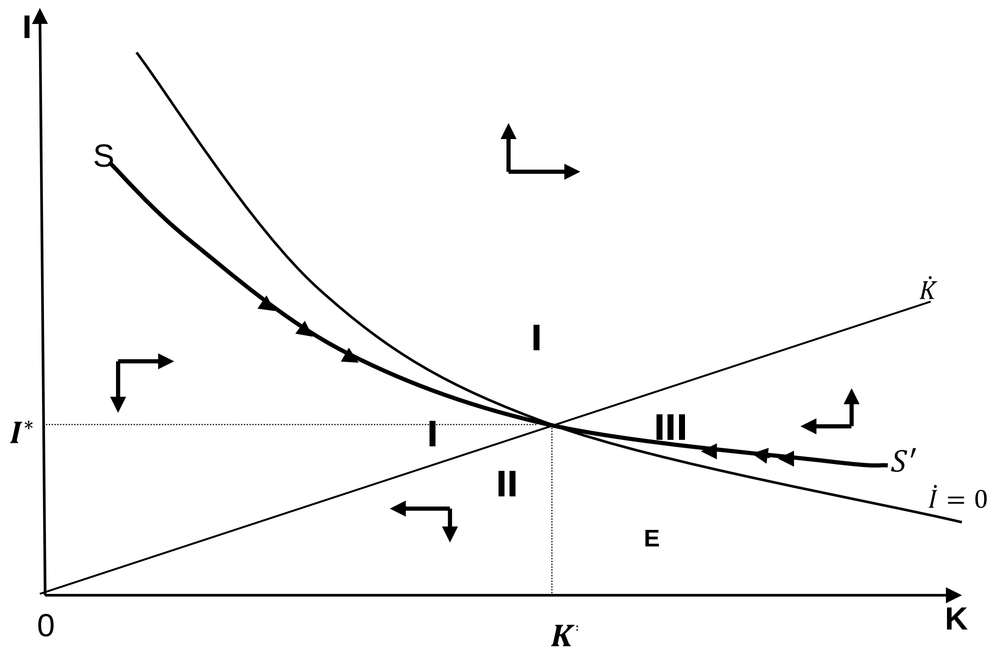


Figure 4.1 characterises the solution of system (4.5) - (4.14) in the nonnegative part of the (I, K) plane. When the tradables production function is strictly

concave, the locus of $\dot{I} = 0$ is a downward slopping curve. The equality in Equation (4.42) happens when the tradable sector production function is constant returns to scale. In that case, the locus of $\dot{I} = 0$ is a horizontal line. It can be shown from Equation (4.14) that $\dot{I}$ is an increasing function of I and then $\dot{I}$ is negative (or positive) at any point below (or above) the locus $\dot{I} = 0$. Similarly, $\dot{K}$ is negative (or positive) at any point below (or above) the locus $\dot{K} = 0$. The moving direction of a point located in one of four regions I, II, II and IV is illustrated by the arrows. To converge to the steady state, the optimal saddle path SS'must lie in regions I and III and thereby being a downward slopping curve.

In Figure 4.1, the steady state (I^*, K^*) is characterised as a saddle point. This property can be confirmed by linearising the differential Equations (4.5) and (4.14) around the steady state (K^*, I^*).

$$\begin{bmatrix} \dot{K} \\ \dot{I} \end{bmatrix} = \begin{bmatrix} N_K & N_I \\ M_K & M_I \end{bmatrix} \begin{bmatrix} K - K^* \\ I - I^* \end{bmatrix} \tag{4.43}$$

where

$$\mathrm{N_K} = \left.\frac{\partial \dot{K}}{\partial \mathrm{K}}\right|_{(I^*,K^*)} = -\varphi \tag{4.44}$$

$$\mathrm{N}_I = \left.\frac{\partial \dot{K}}{\partial \mathrm{I}}\right|_{(I^*,K^*)} = 1 \tag{4.45}$$

$$\mathrm{M_K} = \left.\frac{\partial \dot{I}}{\partial \mathrm{K}}\right|_{(I^*,K^*)} = -\left.\frac{\frac{\partial^2 Q(K, L^T)}{\partial K^2} + \frac{\partial^2 Q(K, L^T)}{\partial K \partial L^T}\frac{\partial L^T}{\partial K}}{\frac{\partial^2 C(I)}{\partial I^2}}\right|_{(I^*,K^*)}$$

Substitute Equation (4.19) into the above equation and combine with Equation (4.23) to examine the sign of $\mathrm{M_K}$

$$\mathrm{M_K} > 0 \tag{4.46}$$

$$\mathrm{M}_I = \frac{\partial \dot{I}}{\partial \mathrm{I}}\bigg|_{(I^*,K^*)}$$

$$= \frac{(\vartheta+\varphi)\left(\frac{\partial^2 C(I)}{\partial I^2}\right)^2 - \frac{\partial^3 C(I)}{\partial I^3}\left(\frac{\partial C(I)}{\partial I}(\vartheta+\varphi) - \frac{\partial Q(K,L^T)}{\partial K}\right)}{\left(\frac{\partial^2 C(I)}{\partial I^2}\right)^2}\Bigg|_{(I^*,K^*)}$$

$$= (\vartheta+\varphi) > 0 \tag{4.47}$$

Due to Equations (4.44-4.47), the determinant of the Jacobian matrix of Equation (4.43) is negative and the saddle point property of the steady state is demonstrated.

4.2.4 The impact of a RER movement depreciation

Now consider a one-time, permanent, unanticipated movement of the RER. For example, such a depreciation could result from a change in economic agents' consumption preference between tradable and non-tradable goods. It is now shown that an RER depreciation shifts the locus $\dot{I} = 0$ upward.

Consider the condition for the locus $\dot{I} = 0$. From Equation (4.14)

$$\Gamma(I,e) = \frac{\partial C(I)}{\partial I}(\vartheta+\varphi) - \frac{\partial Q(K,L^T)}{\partial K} = 0 \tag{4.48}$$

$$\Rightarrow \quad \frac{\partial \Gamma(I,e)}{\partial I}dI + \frac{\partial \Gamma(I,e)}{\partial e}de = 0 \tag{4.49}$$

$$\Rightarrow \quad (\vartheta+\varphi)\frac{\partial^2 C(I)}{\partial I^2}dI - \frac{\partial}{\partial e}\left(\frac{\partial Q(K,L^T)}{\partial K}\right)de = 0 \tag{4.50}$$

$$\Rightarrow \quad (\vartheta+\varphi)\frac{\partial^2 C(I)}{\partial I^2}dI - \frac{\partial^2 Q(K,L^T)}{\partial K \partial L^T}\frac{\partial L^T}{\partial e}de = 0 \tag{4.51}$$

$$\Rightarrow \quad \left.\frac{dI}{de}\right|_{\substack{\dot{I}=0 \\ K\ constant}} = \left(\frac{\partial^2 Q(K, L^T)}{\partial K \partial L^T}\frac{\partial L^T}{\partial e}\right) \Big/ \left((\vartheta + \varphi)\frac{\partial^2 C(I)}{\partial I^2}\right) \tag{4.52}$$

From Equation (4.3)

$$\frac{\partial Q(K, L^T)}{\partial L^T} = \frac{w}{e} \tag{4.53}$$

Differentiate both sides of Equation (4.53) with respect to e

$$\frac{\partial^2 Q(K, L^T)}{\partial {L^T}^2}\frac{\partial L^T}{\partial e} = -\frac{w}{e^2} \tag{4.54}$$

since $\frac{\partial^2 Q(K, L^T)}{\partial {L^T}^2} < 0$ as the tradables production function is concave

$$\frac{\partial L^T}{\partial e} = -\frac{w}{e^2} \Big/ \frac{\partial^2 Q(K, L^T)}{\partial {L^T}^2} > 0 \tag{4.55}$$

and because the tradable sector production function does not have perfect substitution between inputs.

$$\frac{\partial^2 Q(K, L^T)}{\partial K \partial L^T} > 0 \tag{4.56}$$

Provided that $\frac{\partial^2 C(I)}{\partial I^2} > 0$ due to the convexity of the investment cost function, substitute Equations (4.55) and (4.56) into Equations (4.52)

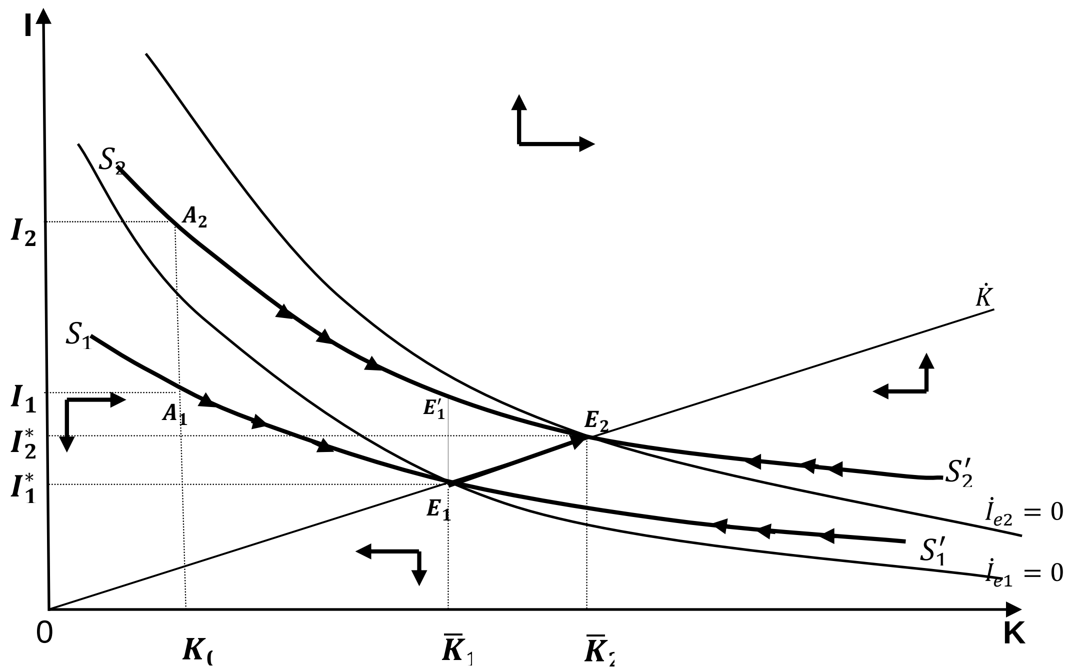
$$\left.\frac{dI}{de}\right|_{\substack{\dot{I}=0 \\ K\ constant}} > 0 \tag{4.57}$$

Thus, it is proven that a one-time, permanent, unanticipated depreciation shifts the locus $\dot{I} = 0$ upward.

Figure 4.2 illustrates the behaviour of a representative firm in the tradables sector facing a one-time, permanent, unanticipated depreciation in the RER. As the RER depreciates from e_1 to e_2, the locus $\dot{I}_{e_2} = 0$ replaces the locus $\dot{I}_{e_1} = 0$ and the new steady state E_2 replaces the initial steady state E_1. Therefore, there is a new saddle path S_2S_2' replacing the initial saddle path S_1S_1'. Suppose that the representative firm is at the beginning position $\mathrm{A}1$ on the saddle path S1, with the initial capital stock K_0 and investment level I_1, to respond to the depreciation, the representative firm jumps from$A1$ to $A2$ with higher level of investment.

It can be shown that two saddle paths S_1S_1' and S_2S_2'do not intersect and then with any initial capital stock K_0 lower than the steady state, a depreciation leads to a higher investment level.

Figure 4.2: The effects of an RER depreciation



Lemma 2: *There is no intersection between two saddle paths* S_1S_1' and S_2S_2'.

Proof: The proof is provided for $\forall K \leq K_1^*$. It can be shown that the investment level for the point E_1' in the saddle path S_2S_2' is higher than I_1^*. As the saddle path from E_1' to E_2 lies in region I, the investment level is decreasing over time and then $I_{E_1'} > I_2^* > I_1^*$.

By contradiction, suppose that S_1S_1' and S_2S_2' intersect. Consider the intersection point I_SK_S which is the nearest intersection point to the E_1. $I_{E_1'} > I_1^*$ so due to the continuity of the saddle paths,$I_1 < I_2\ \ \forall K > K_SandK \leq K_1^*$,where I_1K and I_2Karethe points in theS_1S_1' and S_2S_2', respectively. From the initial point I_SK_S, the dynamic systems evolve and asymptotically converge to the steady state points corresponding to the two saddle paths S_1S_1' and S_2S_2'.

On the saddle path S_1S_1'

$$I_1^* = I_S + \int_0^\infty \dot{I}_1 dt \tag{4.58}$$

$$K_1^* = K_S + \int_0^\infty \dot{K}_1 dt \tag{4.59}$$

and on the saddle pathS_2S_2'

$$I_2^* = I_S + \int_0^\infty \dot{I}_2 dt \tag{4.60}$$

$$K_2^* = K_S + \int_0^\infty \dot{K}_2 dt \tag{4.61}$$

Investment growth can be expressed as a function of capital stock, investment level and the RER. From Equation (4.14), take the partial differential of the investment growth with respect to e:

$$\frac{\partial \dot{I}}{\partial e} = -\frac{1}{c''}\frac{\partial Q(K,L^T)}{\partial K \partial L^T}\frac{\partial L^T}{\partial e} \quad (4.62)$$

Due to Equations (4.55) and (4.56)

$$\frac{\partial \dot{I}}{\partial e} < 0 \quad (4.63)$$

Consequently, the investment growth at the initial point $I_S K_S$ is higher in the saddle path $S_1 S_1'$ than the saddle path $S_2 S_2'$

$$\dot{I}_{2,t=0} < \dot{I}_{1,t=0} \quad (4.64)$$

On the other hand, since $\mathrm{I}_1^* < \mathrm{I}_2^*$

$$\int_0^\infty \dot{I}_1 dt < \int_0^\infty \dot{I}_2 dt \quad (4.65)$$

From Equations (4.64) and (4.65), there must be a point $t = T$ such that $\dot{I}_{1,T} = \dot{I}_{2,T}$ and $\dot{I}_{2t} < \dot{I}_{1t}, \forall t < T$, and then

$$I_{1,p} = I_s + \int_0^p \dot{I}_1 dt > I_{2,p} = I_s + \int_0^p \dot{I}_2 dt \;\; \forall p \leq T \quad (4.66)$$

Moreover, transform the differential Equation (4.5) and multiply both sides by the factor $exp(\varphi t)$:

$$\dot{\mathrm{K}} exp(\varphi t) + \varphi K exp(\varphi t) = \mathrm{I} exp(\varphi t) \quad (4.67)$$

$$\Rightarrow \quad \frac{\mathrm{d}(K exp(\varphi t))}{\mathrm{dt}} = \mathrm{I} exp(\varphi t) \quad (4.68)$$

$$\Rightarrow \qquad K exp(\varphi t) = \int \mathrm{I} exp(\varphi t)\,\mathrm{dt} \tag{4.69}$$

Thereby

$$\left(K_{1,T} - K_0\right) exp(\varphi t) = \int_0^{\mathrm{T}} \mathrm{I}_1 exp(\varphi t)\,\mathrm{dt} \tag{4.70}$$

$$\left(K_{2,T} - K_0\right) exp(\varphi t) = \int_0^{\mathrm{T}} \mathrm{I}_2 exp(\varphi t)\,\mathrm{dt} \tag{4.71}$$

From Equations (4.66), (4.70) and (4.71), it is obvious that

$$K_{2,T} < K_{1,T} \tag{4.72}$$

Consider the point $I_{2,Q}K_{2,Q}$on the saddle path S_2S_2' such that $K_{2,Q} = K_{1,T}$. From Equation (4.72)

$$K_{2,Q} > K_{2,T} \tag{4.73}$$

since the saddle path S_2S_2' is a downward sloping curve

$$I_{2,Q} < I_{2,T} \tag{4.74}$$

On the other hand, it could be derived from Equation (4.66) that

$$I_{2,T} < I_{1,T} \tag{4.75}$$

Combine Equations (4.74) and (4.75)

$$I_{2,Q} < I_{1,T} \tag{4.76}$$

The existence of $I_{1,T}K_{1,T}$ on the saddle path S_1S_1' and $I_{2,Q}K_{2,Q}$ on the saddle path S_2S_2' indicates that an intersection point I_SK_S does not exist as assumed. It is, therefore, proven that two saddle paths S_1S_1' and S_2S_2' do not intersect. Lemma 2 is proved.

4.3 Conclusion

Chapter 4 presents an intertemporal analysis of the investment enhancing effect of an RER depreciation. The model developed is of a small and open economy with two sectors where tradables are produced by capital and labour using a concave production function and non-tradables production is a homogenous function of labour. The optimisation problem uses a representative firm in the tradables sector which maximises its discounted profit. Under the assumption of a strictly convex investment cost function, it was demonstrated that the dynamic system has a saddle point steady state and that the solution to the representative firm's optimisation problem is a feasible path approaching to the steady state.

The effect of a one-time, permanent, unanticipated depreciation in the RER was investigated. Such a depreciation could, for example, result from a structural change in the consumption preference of economic agents. In a phase analysis, it was shown that a depreciation in the RER leads to higher steady state levels of capital stock and investment and also shifts the saddle path upward. This consequently increases the optimal investment rate associated with an arbitrary level of capital stock.

The relationship between the RER and economic growth has been examined for more than two decades. The literature so far has focused mostly on the empirical side of the relationship between a depreciated RER and economic growth, and the theoretical research addressing this issue is at an early stage (P. Montiel & Serven, 2008). The theoretical model provided in this chapter complements the existing literature by looking at the dynamic effect of an RER depreciation on the investment behaviour of a developing economy. While previous theoretical analyses are restricted mainly to the role of a depreciated

RER in loosening the balance of payments constraint in a developing economy (Gala, 2008; Porcile & Lima, 2010) or in counterbalancing market failures and government interventions (Rodrik, 2008), this intertemporal model implicitly follows the neoclassical economic assumption of market perfection.

In this research, the RER is considered as an exogenous variable in the dynamic model. This facilitates the analysis of the investment behaviour of a representative firm in the tradable sector. A change in the consumption preference could be considered as a possible cause of an RER depreciation. The model, however, might be limited in analysing the impact of an RER depreciation originating from a government intervention as there would be other side effects. In further research, it would be important to examine the government's ability to target the RER, and also, to incorporate the influence of government sterilisation into the model.

CHAPTER 5

CALIBRATION MODELS

5.1 Introduction

Since the influential paper of Kydland and Prescott (1982), the calibration technique has become an essential part of the macroeconomic analysis toolkit. This method quickly gathered many adherents and emerged as mainstream in empirical investigation in macroeconomics (Gregory & Smith, 1991). Naturally, following Kydland and Prescott (1982), the use of calibrated models initially focused mostly on real business cycle research. However, the focus has since shifted gradually to other fields and has been used to directly address a number of questions in areas of public finance, growth economics, industry dynamics, political economy and so on (Cooley, 1997). The popularity of calibrated models could be attributed to a number of reasons. In particular, calibrated models are deemed to have more solid theoretical underpinnings than many conventional econometric models. To a large extent, some econometric models are unable to provide conclusive results due to a lack of theoretical grounding. That they are logically consistent is another advantage of calibrated models in comparison with conventional econometric models, which are subject to the "Robert Lucas's critique"[18]. Besides, the calibration method may be easier to implement than many complicated econometric techniques.

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[18] In a well-known article, Lucas Jr (1976) criticised macro-econometric models in forecasting the effects of a policy change. He argued that the parameters of such models were derived from past data and subjected to particular expectations of economic agents in the corresponding periods. However, if a policy changed, such expectations would be changed accordingly and hence the estimated parameters would no longer reflect the true relationship. This, Lucas argued, made macro-econometric models useless in forecasting the outcome of different set of policies.

Because a calibrated model is artificial, it requires numerical values for the parameters in the model to be as rational as possible. The parameters are often provided from related econometric studies or quantified from casual empiricism or sometimes deliberately selected to make the calibrated results mimic some particular features of observed data (Hoover, 1995).

The theoretical model in the Chapter 4 found an investment enhancing effect of a depreciation in the RER. To retain generality, more general forms of the production and investment cost functions were employed. Although this makes the quantitative conclusions about the investment enhancing effect of an RER depreciation more clear-cut, there is no sense of the magnitude of the effects. In order to carry out calibrations, particular forms of production and investment cost function need to be specified without violating the assumptions made in the theoretical model.

This chapter provides two calibrations for the theoretical model developed in the Chapter 4. The aim of calibrated models is to examine the magnitude of the impact caused by a depreciation in the RER on the capital accumulation rate and how this impact is subjected on the parameters in the model. The first calibration is carried under the assumption of constant returns to scale in tradables production. In the second calibration, the restrictive assumption of constant returns to scale in tradables production is removed and a strictly concave form of the tradables production function is considered.

5.2 Calibration with constant returns to scale tradables production function

5.2.1 Model specification

Assuming that the cost function consists of a linear component and a convex component, and then has the form as below:

$$C(I) = I + \gamma I^x;\ \gamma > 0, x > 1 \tag{5.1}$$

Take the first and second derivatives of Equation (5.1) with respect to I

$$C'(I) = 1 + \gamma x I^{x-1} \tag{5.2}$$

$$C''(I) = \gamma x(x-1) I^{x-2} \tag{5.3}$$

The production function of the tradable sector is assumed to be a constant returns to scale Cobb-Douglas form:

$$Q^T(K, L^T) = AK^{\alpha} {L^T}^{1-\alpha}; A > 0, 0 < \alpha < 1 \tag{5.4}$$

where α is the capital income share in the tradables sector.

Substitute Equation (5.4) into Equation (4.3) in order to represent the labour in the tradables sector as a function of capital stock:

$$\frac{\partial Q(K, L^T)}{\partial L^T} = A(1-\alpha)K^{\alpha} {L^T}^{-\alpha} = \frac{w}{e} \tag{5.5}$$

$$\Rightarrow \quad L^T = \left(\frac{w}{A(1-\alpha)e}\right)^{\frac{-1}{\alpha}} K \tag{5.6}$$

Thereby:

$$MPK \equiv \frac{\partial Q(K, L_T)}{\partial K} \tag{5.7}$$

$$\Rightarrow \quad MPK = A\alpha K^{\alpha-1} {L_T}^{1-\alpha} \tag{5.8}$$

$$\Rightarrow \quad MPK = A\alpha \left(\frac{w}{A(1-\alpha)e}\right)^{\frac{\alpha-1}{\alpha}} \tag{5.9}$$

where MPK is the marginal product to capital in the tradables sector.

Substitute Equations (5.2), (5.3) and (5.7) into Equation (4.14) to derive a specific form of investment growth function:

$$\dot{I} = \frac{(1 + \gamma x I^{x-1})(\vartheta + \varphi) - MPK}{\gamma x (x-1) I^{x-2}} \tag{5.10}$$

5.2.2 Steady state

The steady state of the dynamic system is characterised by a constant level of investment and capital ($\dot{I} = 0, \dot{K} = 0$). The steady state level of investment, I^*, can be derived from Equation (5.10).

$$\frac{\left(1 + \gamma x I^{*(x-1)}\right)(\vartheta + \varphi) - MPK}{\gamma x (x-1) I^{*(x-2)}} = 0 \tag{5.11}$$

$$\Leftrightarrow \qquad \left(1 + \gamma x I^{*(x-1)}\right)(\vartheta + \varphi) - MPK = 0 \tag{5.12}$$

$$\Leftrightarrow \qquad I^{*(x-1)} = \left(\frac{MPK}{\vartheta + \varphi} - 1\right)\frac{1}{\gamma x} \tag{5.13}$$

$$\Leftrightarrow \qquad I^* = \left(\frac{\left(MPK - (\vartheta + \varphi)\right)}{(\vartheta + \varphi)\gamma x}\right)^{\frac{1}{x-1}} \tag{5.14}$$

Notably, the condition for the existence of the steady state is that $MPK > (\vartheta + \varphi)$.

Substitute Equation (5.14) into Equation (4.5)

$$K^* = \frac{I^*}{\varphi} \tag{5.15}$$

$$\Rightarrow \qquad K^* = \frac{1}{\varphi}\left(\frac{\left(MPK - (\vartheta + \varphi)\right)}{(\vartheta + \varphi)\gamma x}\right)^{\frac{1}{x-1}} \tag{5.16}$$

It can be shown that in the case of a constant returns to scale tradables production function, the investment level is held constant at the steady state level. In other words, the saddle path is a vertical line in a (I, K) plane as illustrated in the phase analysis in the Chapter 4. From Equation (5.10), the investment growth rate will be negative if the level of investment is lower than the steady state. Therefore, if a saddle path starts from an initial level of investment lower than I^*, the investment growth will be negative and the dynamic system will end up with a level lower than I^* over an infinite horizontal. Similarly, if a saddle path starts from an initial level of investment higher than I^*, the investment growth will be positive and the dynamic system will not converge to the steady state. Therefore, from Equation (4.5):

$$\dot{K} = -\varphi K + I^* \tag{5.17}$$

Transform and multiply both sides of Equation (5.17) with the factor: $exp(\varphi t)$

$$\dot{K} + \varphi K = I^* \tag{5.18}$$

$$\Rightarrow \quad \dot{K} \exp(\varphi t) + \varphi K \exp(\varphi t) = I^* \exp(\varphi t) \tag{5.19}$$

Take the integral of both sides of Equation (5.19)

$$K \exp(\varphi t) = \int I^* \exp(\varphi t)\, dt \tag{5.20}$$

$$K \exp(\varphi t) = \frac{I^*}{\varphi} \exp(\varphi t) + U \tag{5.21}$$

$$K = \frac{I^*}{\varphi} + U \exp(-\varphi t) \tag{5.22}$$

Where U is a constant. Take derivative Equation (5.22) with respect to t

$$\dot{K} = -U\varphi \exp(-\varphi t) \tag{5.23}$$

Combine Equations (5.15), (5.22) and (5.23)

$$\dot{K} = (K^* - K)\varphi \tag{5.24}$$

and hence derive a function of the capital accumulation rate as below

$$\frac{\dot{K}}{K} = \frac{\varphi K^*}{K} - \varphi \tag{5.25}$$

Equation (5.25) implies that the capital accumulation rate depends on the depreciation rate of capital and the distance from an initial value of capital stock to the steady state. To examine the effect of a one-time, permanent, unanticipated depreciation in the RER on the rate of capital accumulation, differentiate Equation (5.25) with respect to e:

$$\frac{\partial}{\partial e}\left(\frac{\dot{K}}{K}\right) = \frac{-\varphi}{K}\frac{\partial K^*}{\partial e} \tag{5.26}$$

From Equation (5.16)

$$\frac{\partial \mathrm{K}^*}{\partial e} = \frac{1}{\varphi}\frac{1}{x-1}\left(\frac{1}{(\vartheta+\varphi)\gamma x}\right)^{\frac{1}{x-1}}\left(MPK - (\vartheta+\varphi)\right)^{\frac{2-x}{x-1}}\frac{\partial MPK}{\partial e} \tag{5.27}$$

From Equation (5.9)

$$\frac{\partial MPK}{\partial e} = MPK\frac{1-\alpha}{\alpha e} \tag{5.28}$$

Substitute Equation (5.28) into Equation (5.27)

$$\frac{\partial \mathrm{K}^*}{\partial e} = \frac{1}{\varphi}\frac{1}{x-1}\left(\frac{1}{(\vartheta+\varphi)\gamma x}\right)^{\frac{1}{x-1}}\left(MPK-(\vartheta+\varphi)\right)^{\frac{2-x}{x-1}} MPK\frac{1-\alpha}{\alpha e} \quad (5.29)$$

Combine Equation (5.16) and Equation (5.29)

$$\frac{\partial \mathrm{K}^*}{\partial e} = \frac{1}{x-1}\frac{\mathrm{K}^*}{\left(MPK-(\vartheta+\varphi)\right)} MPK\frac{1-\alpha}{\alpha e} \quad (5.30)$$

Substitute Equation (5.30) into Equation (5.26)

$$\frac{\partial}{\partial e}\left(\frac{\dot{K}}{K}\right) = \varphi\frac{\mathrm{K}^*}{\mathrm{K}}\frac{1}{x-1}\frac{MPK(1-\alpha)}{\left(MPK-(\vartheta+\varphi)\right)\alpha e} \quad (5.31)$$

Equation (5.31) demonstrates that a depreciation in the RER shifts the steady state of capital to a higher level. Therefore, it lengthens the distance between an initial capital stock level and the steady state, and leads to a higher rate of capital accumulation.

From Equation (5.31):

$$\Delta\frac{\dot{K}}{K} \approx \frac{\partial}{\partial e}\left(\frac{\dot{K}}{K}\right)\Delta e \quad (5.32)$$

$$\Delta\frac{\dot{K}}{K} \approx \varphi\frac{\mathrm{K}^*}{\mathrm{K}}\frac{1}{x-1}\frac{MPK(1-\alpha)}{\left(MPK-(\vartheta+\varphi)\right)\alpha}\frac{\Delta e}{e} \quad (5.33)$$

Equation (5.33) shows that an increase in the capital accumulation rate is a linear function of the percentage change in the RER. Equation (5.33) can be re-written as

$$\Delta\frac{\dot{K}}{K} \approx \zeta\frac{\Delta e}{e} \quad (5.34)$$

where

$$\zeta \equiv \frac{\varphi}{\mu}\frac{1}{x-1}\frac{MPK(1-\alpha)}{\big(MPK-(\vartheta+\varphi)\big)\alpha} \tag{5.35}$$

$$\mu \equiv \frac{\mathrm{K}}{\mathrm{K}^{*}} \tag{5.36}$$

In Equation (5.34), ζ is a multiplier representing the magnitude response of the capital accumulation rate to a depreciation in the RER. In other words, a 1% depreciation of the RER leads to ζ % increase in the capital accumulation rate.

5.2.3 Calibration

5.2.3.1 Model parameters and the justification

Because the value of ζ represents the magnitude response of the capital accumulation rate to a depreciation in the RER, the calibration focuses on economic factors affecting the value of ζ which are in fact components in the right hand side of Equation (5.35). The benchmark parameters of these economic factors are summarised in Table 5.1. All flow variables are measured annually.

Typically, in the literature the subjective discount rate is assumed to be equal the real interest rate. This study employs a subjective discount rate of 0.05. This figure is consistent with other calibration models (e.g. Kydland and Prescott (1982) assumed a rate of 0.04) and statistical data on East Asian countries (Figure 5.1).

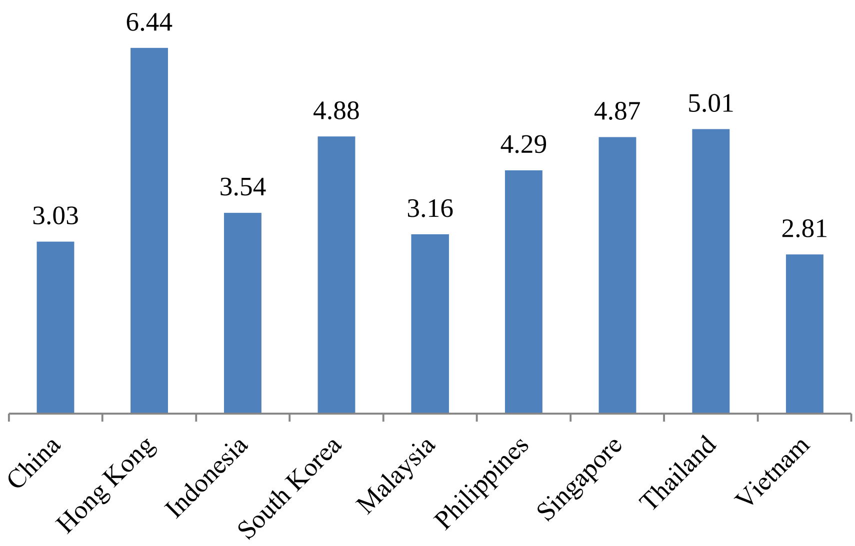
The benchmark value of the capital depreciation rate is 0.1. This rate is in line with other calibration studies and empirical evidence from developing countries. For example, it is equal to the figure set by Kydland and Prescott (1982) in their real business cycle model. Schündeln (2013) found that the capital depreciation rate in Indonesian manufacturing firms in range 0.08-0.14. Qian and Zhu (2012) reported the capital depreciation rate in Chinese manufacturing firms is about 0.09-0.12 (Table 5.2).

Table 5.1: Model parameters in the constant returns scenario

Coefficients	Description	Value
φ	Capital depreciation rate	0.1
ϑ	Subjective discount rate	0.05
$1-\alpha$	Labour income share in the tradable sector	0.25
μ	Ratio of capital stock to the steady state level	0.2
MPK	Marginal product to capital in the tradable sector	0.3
x	The exponent in the investment cost function	1.75

Source: The *author*

Figure 5.1: The real interest rate in East Asian countries, on average 1996-2013 (%)



Source*: The author's calculation from data provided by World Databank*

Table 5.2: Capital depreciation and labour income shares in Chinese manufacturing firms

Year	Number of observations	Capital depreciation	Labour income share
1998	12348	0.12	0.29
1999	13484	0.12	0.27
2000	15200	0.12	0.26
2001	15790	0.12	0.25
2002	17652	0.11	0.24
2003	20393	0.1	0.22
2004	18082	0.09	0.21
2005	23970	0.1	0.2
2006	26963	0.09	0.2
2007	31001	0.09	0.19

Source*: Qian and Zhu (2012)*

The benchmark labour income share in the tradable sectors is set to 0.75. This figure is consistent with recent empirical reports on the labour income share in the manufacturing industries, i.e. Qian and Zhu (2012). Based on data at the four digit industry level, Qian and Zhu (2012) showed that the labour income share in Chinese manufacturing industries is around 25% of value-added (with tax included) (Table 5.2). Onaran (2004) combined different source of data such as OECD STAN database, WDI database, EIU database, and national survey statistics and reported the average labour share in the industrial sector in developing countries is in the range from 13.32% to 41.83% over the period 1980-2003 (Table 5.3).

Table 5.3: Labour income shares in manufacturing sectors in developing countries

Country	***1970-1979***	***1980-2003***
Argentina	25.07	16.54
Brazil	30.49	29.47
Chile	42.85	34.59
Indonesia	24.28	20.79
Korea	34.91	41.83
Malaysia	27.51	26.94
Mexico	55.22	34.06
Philippines	11.44	13.32
Thailand	20.27	31.16
Turkey	30.71	20.29

Source*: Onaran (2004)*

The marginal product of capital is assigned to be 0.3 in the benchmark case. This figure is consistent with the empirical literature. For example, Caselli and Feyrer (2007) reported the average marginal product of capital among 29 developing countries of 0.27. Rondi and Elston (2009) estimated the marginal product of capital in 43 Italian firms which went to an initial public offering in 1990s and reported the figure of 0.205. Based on Bai, Hsieh, and Qian (2006)'s data on capital share of income and capital to output ratio (Table 5.4), the marginal product of capital in China is estimated at about 0.33 on average over the period 1990-2005.

Table 5.4: The marginal product of capital in China

Year	*Capital share of income*	*Capital to output ratio*	*Marginal product of capital*
1990	0.47	1.49	0.31
1991	0.50	1.44	0.35
1992	0.50	1.36	0.37
1993	0.50	1.31	0.38
1994	0.49	1.39	0.35
1995	0.47	1.37	0.35
1996	0.47	1.39	0.34
1997	0.47	1.48	0.32
1998	0.47	1.57	0.30
1999	0.48	1.64	0.29
2000	0.49	1.63	0.30
2001	0.49	1.65	0.29
2002	0.49	1.67	0.29
2003	0.50	1.66	0.30
2004	0.54	1.63	0.33
2005	0.59	1.72	0.34

Source*: Bai et al. (2006) and author's calculation*

The ratio of the capital stock to the steady state level is set to 0.2 in the benchmark model. This figure could be reasonably inferred from the ratio of examined developing countries' per capita income to the level in developed countries. The ratio of 0.2 could fit into the cases of high middle-income countries, which constitute a majority in the countries examined in the following empirical chapters.

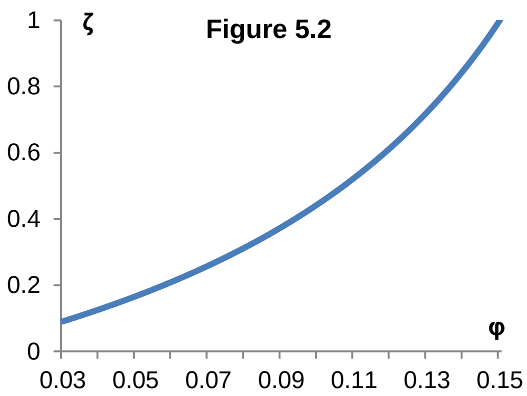
Unfortunately, there is no guidance from the related empirical literature for choosing a rational value of the benchmark exponent in the investment cost function. The benchmark value chosen is 1.75. Due to parameter uncertainty in the calibration method, there is always a high degree of uncertainty in the calibrated results. To capture this uncertainty, sensitivity analysis is performed.

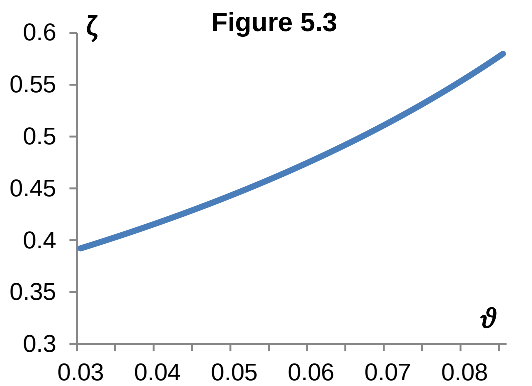
5.2.3.2 The calibration result and sensitivity analyses

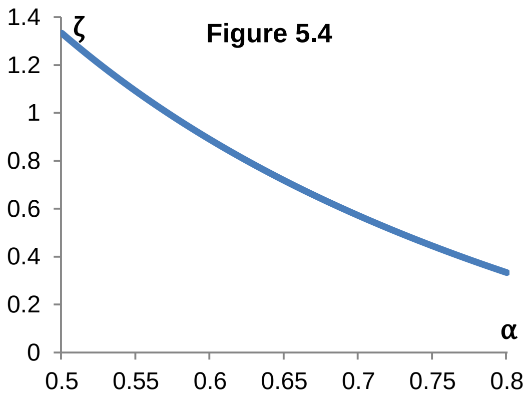
In the benchmark model using the parameters provided in Table 5.2, the multiplier ζ has a value of 0.4444. This means that a 1% depreciation in the RER leads to an increase of 0.4444% in the rate of capital accumulation. Figures 5.2-5.7 illustrate the dependence of the multiplier ζ on the model parameters.

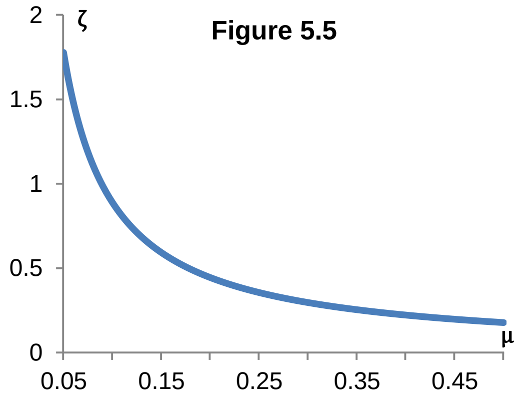
Figure 5.2 depicts the multiplier ζ as a function of the capital depreciation rate φ. This is a convex upward function as the slope of the curve rises when the capital depreciation rate increases. This implies a stronger investment enhancing effect from an RER depreciation in an economy with a high capital depreciation rate. The assigned value of the capital depreciation seems to influence significantly the magnitude of the investment enhancing effect of an RER depreciation. An increase of 10% in the capital depreciation rate from the benchmark value causes the multiplier ζ to increase 17.9% while a decrease of 10% in the capital depreciation rate causes the multiplier ζ to decrease 15.6%.

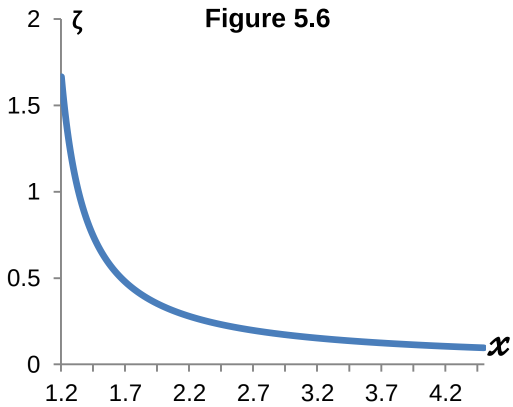
In Figure 5.3, the graph representing the relationship between the multiplier ζ and the subjective discount rate ϑ also has an increasing slope. Similar to the capital depreciation rate, a higher subjective discount rate corresponds to higher value of the multiplier ζ and stronger investment enhancing effect of an RER depreciation. The slope of the multiplier ζ also rises as the subjective discount rate increases. However, it seems that the multiplier ζ is less sensitive to fluctuations in the subjective discount rate than to the capital depreciation

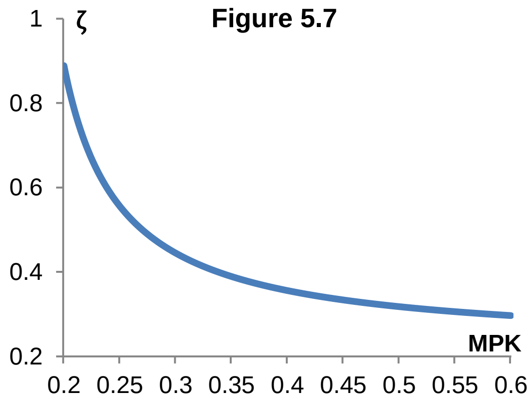












Source: *The author*

Figure 5.2: The depreciation rate and the multiplier ζ

Figure 5.3: The subjective discount rate and the multiplier ζ

Figure 5.4: The capital income share and the multiplier ζ

Figure 5.5: The capital stock and the multiplier ζ

Figure 5.6: The investment cost function and the multiplier ζ

Figure 5.7: The marginal production to capital and the multiplier ζ

rate. An increase of 10% in the subjective discount rate from the benchmark value causes the multiplier ζ to increase by 3.4% while a decrease of 10% in the capital depreciation rate causes the multiplier $\zeta$to decrease 3.2%.

Figure 5.4 illustrates the negative relationship between the multiplier ζ and the capital income share in the tradables sector. This relationship is a convex downward function and the multiplier ζ increases steeply as the capital income share in the tradables sector decreases. The magnitude of the investment enhancing effect of an RER depreciation appears to be very sensitive as the selected value of the capital income share in the tradables sector decreases. A decrease of 10% in the value of the capital income share in the tradables sector from the benchmark value causes the multiplier ζ to increase 44.4% while an increase of 10% in the value of the capital income share from the benchmark value makes the multiplier ζ decrease 36.4%.

Figure 5.5 shows that the lower the ratio of the capital stock to the steady state level, the higher the value of the multiplier ζ. The curve has a convex downward shape and the slope is steeper with lower values of μ. This has an important economic implication that the impact of an RER depreciation could be more robust in a less developed country. The selected value of μ affects the calibrated result significantly. A decrease of 10% in the value of μ from the benchmark value leads to an 11% increase in the value of ζ, and an increase of 10% in the value of μ causes the multiplier ζ to decrease by 9%.

Figure 5.6 has a convex downward shape reflecting the correlation between the multiplier ζ and the exponent in the investment cost function. In particular, when the exponent in the investment cost function approaches unity, the value of the multiplier ζ becomes extremely large. This is due to that the convexity of the investment cost function required to smooth the adjustment process of the dynamic system. When the exponent in the investment cost function approaches unity, the investment cost function becomes close to a linear function. In this case, the adjustment process to a new steady state level happens almost instantaneously. The value of the multiplier ζ seems to be sensitive to the selected value of x. A decrease of 10% in the value of x causes the multiplier ζ to increase 30% while an increase of 10% in the value of x causes the multiplier ζ to decrease 19%.

Finally, Figure 5.7 illustrates the correlation between the marginal product of capital and the multiplier ζ. Similar to the cases of the ratio of the capital stock to the steady state level and the exponent in the investment cost function, the multiplier $\zeta$is a convex downward function of the marginal product of capital. The effect of an RER depreciation on the capital accumulation rate is large with small values of MPK. The sensitivity shows that the value of the multiplier ζ is moderately sensitive to the selected value of MPK. An increase of 10% in the marginal product of capital from the benchmark value causes the multiplier $\zeta$to decrease 8.3%, while a decrease of 10% in the marginal product of capital from the benchmark value causes the multiplier ζ to decrease 12.5%

5.3 Calibration with a decreasing returns to scale tradables production function

In Section 5.2, a calibrated model using the assumption of a constant returns to scale tradables production function is examined. While the constant returns to scale Cobb-Douglas form allows a closed form solution of the optimisation problem ((4.4)-(4.6)), a general strictly concave function form for the tradables production function, which is examined in this section, precludes a closed form of the solution to the optimisation problem. Hence, the dynamic linearisation technique is applied to derive, approximately, the capital accumulation rate of a point in the vicinity of the steady state.

The error of the linearised dynamics increases as the investigated point goes far from the steady state. Hence, the calibration in this section is deliberately carried out at points neighbouring the steady state. A higher ratio of capital to the steady state capital is chosen and a set of parameters in the model is chosen to consistent with a more developed economy.

5.3.1 Model specification

Assume the investment cost function has the form:

$$C(I) = \gamma I^{x};\ \gamma > 0, x > 1 \tag{5.37}$$

Where γ is a positive integer.Take the first and second derivatives of Equation (5.37) with respect to I

$$c'(I) = \gamma x I^{x-1} \tag{5.38}$$

$$c''(I) = \gamma x(x-1)I^{x-2} \tag{5.39}$$

The production function of the tradable sector is assumed to follow a Cobb-Douglas form

$$Q^{T}(K, L^{T}) = AK^{\alpha}{L^{T}}^{\beta}; 0 < \alpha < 1 \tag{5.40}$$

where A is a positive constant and α is the capital income share of the tradables production function.

Substitute Equation (5.40) into Equation (4.3):

$$\frac{\partial Q(K, L_T)}{\partial L_T} = A(1-\alpha)K^{\alpha}{L_T}^{\beta-1} = \frac{w}{e} \tag{5.41}$$

$$L_T = \left(\frac{w}{A(1-\alpha)e}\right)^{\frac{1}{\beta-1}} K^{\frac{\alpha}{1-\beta}} \tag{5.42}$$

Thereby

$$\frac{\partial Q(K, L_T)}{\partial K} = A\alpha K^{\alpha-1}{L_T}^{\beta} \tag{5.43}$$

$$= \theta K^{\frac{\alpha+\beta-1}{1-\beta}}$$

where

$$\theta = A\alpha\left(\frac{w}{A(1-\alpha)e}\right)^{\frac{\beta}{\beta-1}} \tag{5.44}$$

Substitute Equations (5.38), (5.39) and (5.43) into Equation (4.14)

$$\dot{I} = \frac{(\gamma x I^{x-1})(\vartheta+\varphi) - \theta K^{\frac{\alpha+\beta-1}{1-\beta}}}{\gamma x(x-1)I^{x-2}} \tag{5.45}$$

5.3.2 Steady state

From Equation (5.45)

$$\dot{I}\big|_{(K^*,I^*)} = \frac{\left(\gamma x I^{*x-1}\right)(\vartheta+\varphi) - \theta K^{*\frac{\alpha+\beta-1}{1-\beta}}}{\gamma x(x-1)I^{*x-2}} = 0 \tag{5.46}$$

$$\Leftrightarrow \quad \left(\gamma x I^{*(x-1)}\right)(\vartheta+\varphi) - \theta K^{*\frac{\alpha+\beta-1}{1-\beta}} = 0 \tag{5.47}$$

Substitute Equation (4.5) into Equation (5.47)

$$\gamma x(\vartheta+\varphi)\varphi^{(x-1)}K^{*(x-1)} - \theta K^{*\frac{\alpha+\beta-1}{1-\beta}} \tag{5.48}$$

$$\Leftrightarrow \quad \gamma x(\vartheta+\varphi)\varphi^{(x-1)}K^{*\left((x-1)-\frac{\alpha+\beta-1}{1-\beta}\right)} = \theta \tag{5.49}$$

$$\Leftrightarrow \quad K^{*\left(\frac{x-x\beta-\alpha}{1-\beta}\right)} = \frac{\theta}{\gamma x(\vartheta+\varphi)\varphi^{(x-1)}} \tag{5.50}$$

$$\Leftrightarrow \qquad K^* = \left(\frac{\theta}{\gamma x(\vartheta + \varphi)}\right)^{\frac{1-\beta}{x - x\beta - \alpha}} \varphi^{\frac{1 + x\beta - x - \beta}{x - x\beta - \alpha}} \tag{5.51}$$

$$\Leftrightarrow \qquad I^* = \left(\frac{\theta}{\gamma x(\vartheta + \varphi)}\right)^{\frac{1-\beta}{x - x\beta - \alpha}} \varphi^{\frac{1-\beta-\alpha}{x - x\beta - \alpha}} \tag{5.52}$$

5.3.3 Linearised dynamics

Consider the linearised dynamics of the system Equation (4.5) and Equation (5.45) at the steady state.

$$\begin{bmatrix} \dot{K} \\ \dot{I} \end{bmatrix} = \begin{bmatrix} \mathrm{N_K} & \mathrm{N}_I \\ \mathrm{M_K} & \mathrm{M}_I \end{bmatrix} \begin{bmatrix} \mathrm{K} - \mathrm{K}^* \\ I - I^* \end{bmatrix} \tag{5.53}$$

where

$$\mathrm{N_K} = \left.\frac{\partial \dot{K}}{\partial \mathrm{K}}\right|_{(\mathrm{I,K}) = (I^*, K^*)} = -\varphi \tag{5.54}$$

$$\mathrm{N}_I = \left.\frac{\partial \dot{K}}{\partial \mathrm{K}}\right|_{(\mathrm{I,K}) = (I^*, K^*)} = 1 \tag{5.55}$$

$$\begin{aligned} \mathrm{M_K} = \left.\frac{\partial \dot{I}}{\partial \mathrm{K}}\right|_{(\mathrm{I,K}) = (I^*, K^*)} &= -\frac{\theta K^{*\frac{\alpha+\beta-1}{1-\beta}}}{\gamma x(x-1) I^{*x-2}} \frac{\alpha + \beta - 1}{(1-\beta)K^*} \\ &= -\frac{\left(\gamma x I^{*x-1}\right)(\vartheta + \varphi)}{\gamma x(x-1) I^{*x-2}} \frac{\alpha + \beta - 1}{(1-\beta)K^*} \\ &= -\frac{(\alpha + \beta - 1)(\vartheta + \varphi) I^*}{(1-\beta)(x-1)K^*} \\ &= -\frac{\alpha + \beta - 1}{1 - \beta} \frac{(\vartheta + \varphi)\varphi}{(x-1)} > 0 \end{aligned} \tag{5.56}$$

$$\mathrm{M}_I = \left.\frac{\partial \dot{I}}{\partial \mathrm{I}}\right|_{(\mathrm{I,K})=(I^*,K^*)} = (\vartheta + \varphi) > 0 \tag{5.57}$$

Examine the trace and determinant of the Jacobian matrix

$$\begin{aligned} det\begin{pmatrix} \mathrm{N_K} & \mathrm{N}_I \\ \mathrm{M_K} & \mathrm{M}_I \end{pmatrix} &= -\varphi(\vartheta+\varphi) + \frac{\alpha+\beta-1}{1-\beta}\frac{(\vartheta+\varphi)\varphi}{(x-1)} \\ &= -\varphi(\vartheta+\varphi)\left(1-\frac{\alpha+\beta-1}{(1-\beta)(x-1)}\right) \\ &= -\varphi(\vartheta+\varphi)\left(\frac{x-x\beta-\alpha}{(1-\beta)(x-1)}\right) \end{aligned} \tag{5.58}$$

$$Tr\begin{pmatrix} \mathrm{N_K} & \mathrm{N}_I \\ \mathrm{M_K} & \mathrm{M}_I \end{pmatrix} = \vartheta \tag{5.59}$$

Because the determinant of the Jacobian matrix is negative, the roots are real and have opposite signs. The steady state is, therefore, a saddle point. Let τ denote the negative, stable eigenvalue of the Jacobian matrix.

$$\tau = \frac{1}{2}\left(\vartheta - \sqrt{\vartheta^2 + 4\varphi(\vartheta+\varphi)\left(\frac{x-x\beta-\alpha}{(1-\beta)(x-1)}\right)}\right) \tag{5.60}$$

and hence

$$\dot{K} \approx \tau(K - \mathrm{K}^*) \tag{5.61}$$

$$\frac{\dot{K}}{K} \approx \tau\left(1 - \frac{\mathrm{K}^*}{\mathrm{K}}\right) \tag{5.62}$$

Equation (5.62) implies that the capital accumulation rate is a function of the convergence speed, τ, and the distance from an initial value of capital stock to the steady state. To examine the effect of a one-time, permanent, unanticipated depreciation in the RER on the rate of capital accumulation, both sides of (5.62) are differentiated with respect to e .

$$\frac{\partial}{\partial e}\left(\frac{\dot{K}}{K}\right) \approx -\frac{\tau}{\mathrm{K}}\frac{\partial \mathrm{K}^*}{\partial e} \tag{5.63}$$

From Equations (5.51) and (5.44)

$$\frac{\partial \theta}{\partial e} = A\alpha\left(\frac{w}{A(1-\alpha)e}\right)^{\frac{\beta}{\beta-1}}\frac{-\beta}{\beta-1}\frac{1}{e}$$

$$= \frac{-\beta}{\beta-1}\frac{\theta}{e} \tag{5.64}$$

$$\frac{\partial \mathrm{K}^*}{\partial e} = \frac{1-\beta}{x-x\beta-\alpha}\varphi^{\frac{1+x\beta-x-\beta}{x-x\beta-\alpha}}\left(\frac{\theta}{\gamma x(\vartheta+\varphi)}\right)^{\frac{1-\beta}{x-x\beta-\alpha}}\frac{1}{\theta}\frac{\partial \theta}{\partial e}$$

$$= \frac{1-\beta}{x-x\beta-\alpha}\varphi^{\frac{1+x\beta-x-\beta}{x-x\beta-\alpha}}\left(\frac{\theta}{\gamma x(\vartheta+\varphi)}\right)^{\frac{1-\beta}{x-x\beta-\alpha}}\frac{1}{\theta}\frac{-\beta}{\beta-1}\frac{\theta}{e}$$

$$= K^*\frac{\beta}{x-x\beta-\alpha}\frac{1}{e} \tag{5.65}$$

and hence

$$\frac{\partial}{\partial e}\left(\frac{\dot{K}}{K}\right) \approx -\tau\frac{\mathrm{K}^*}{\mathrm{K}}\frac{\beta}{(x-x\beta-\alpha)}\frac{1}{e} \tag{5.66}$$

Equation (5.66) shows that a depreciation in the RER shifts the steady state of capital to a higher level. Therefore, it lengthens the distance between an initial capital stock level and the steady state, and leads to a higher rate of capital accumulation.

$$\Delta\frac{\dot{K}}{K} \approx -\tau\frac{\mathrm{K}^*}{\mathrm{K}}\frac{\beta}{(x-x\beta-\alpha)}\frac{\Delta e}{e}$$

$$\approx -\frac{1}{2}\left(\vartheta - \sqrt{\vartheta^2 + 4\varphi(\vartheta+\varphi)\left(\frac{x - x\beta - \alpha}{(1-\beta)(x-1)}\right)}\right)\frac{\mathrm{K}^*}{\mathrm{K}}\frac{\beta}{(x - x\beta - \alpha)}\frac{\Delta e}{e}$$

$$\approx \psi\frac{\Delta e}{e} \tag{5.67}$$

where

$$\psi \equiv -\frac{1}{2}\left(\vartheta - \sqrt{\vartheta^2 + 4\varphi(\vartheta+\varphi)\left(\frac{x - x\beta - \alpha}{(1-\beta)(x-1)}\right)}\right)\frac{1}{\mu}\frac{\beta}{(x - x\beta - \alpha)} \tag{5.68}$$

Recall from Equation (5.36) that $= \frac{K}{K^*}$.

Similar to the previous calibrated model for the constant returns to scale case, it can be shown from Equation 0 that the capital accumulation rate is an approximately linear function of the percentage change in the RER. The multiplier ψ represents the response magnitude of the capital accumulation rate to a depreciation in the RER. In particular, a 1% depreciation of the RER leads to ψ% increase in the capital accumulation rate.

5.3.4 Calibration

5.3.4.1 Model parameters and the justification

For the case of a decreasing returns to scale tradables production function, the model parameters are provided in the Table 5.5. From Equation (5.68), the parameters affecting the value of the multiplier ψ include the capital depreciation rate φ, the subjective discount rate ϑ, the exponent of capital in the tradables production α, and the exponent of labour in the tradables production β, the ratio of capital stock to the steady state level μ, and the exponent in the investment cost function x.

Table 5.5: Model parameters in the decreasing returns to scale scenario

Coefficients	Description	Value
φ	Capital depreciation rate	0.1
ϑ	Subjective discount rate	0.05
α	The exponent of capital in the tradables production function	0.5
β	The exponent of labour in the tradables production function	0.4
μ	Ratio of capital stock to the steady state level	0.6
x	The exponent in the investment cost function	1.75

Source: *The author*

While the benchmark values of the capital depreciation rate, the subjective discount rate and the exponent in the investment cost function are same as in the previous calibration model for an economy with constant returns to scale tradables production, the ratio of capital stock to the steady state level is set to be 0.6. As mentioned above, in order to reduce the measurement error caused by the linearisation method, this calibrated model focuses on a more developed economy. The higher value of μ is, therefore, appropriate to fit an economy with higher level of development.

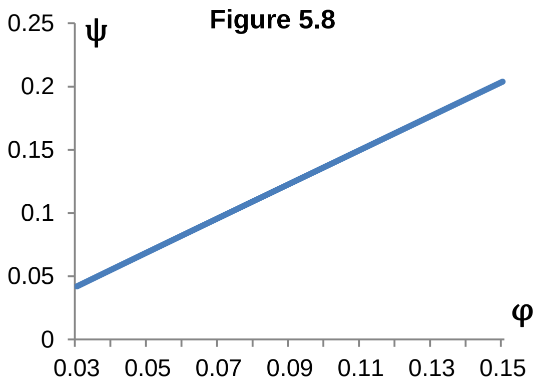
Moreover, the exponent of capital is set to 0.5 and the exponent of labour is set to 0.4. These parameters are in the ranges suggested by empirical studies of industrial economies. For example, Basu and Fernald (1997) estimated a returns to scale factor, which is equivalent to the sum of the exponents of capital and labour in the Cobb-Douglas production function, $\alpha + \beta$, in the US manufacturing sector. They calculated the factor for each two-digit classification manufacturing industry and then used the share of each industry as the weights to derive an aggregate number. The returns to scale factor was reported to be 0.93 in OLS regression and 0.92 in 2SLS regression. Burnside, Eichenbaum, and Rebelo (1995) estimated the coefficients of a Cobb-Douglas production function using three-digit classification manufacturing industry data. The exponent of capital was reported to be 0.35 while the exponent of labour was reported to be 0.52.

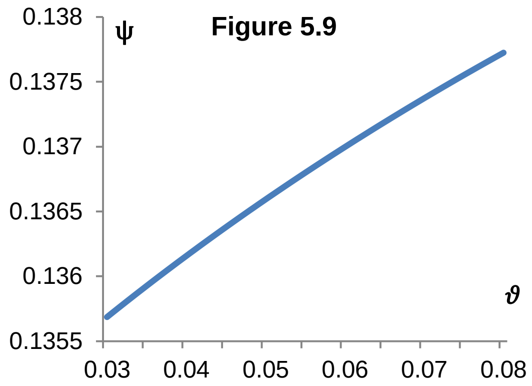
5.3.4.2 The calibration result and sensitivity analyses

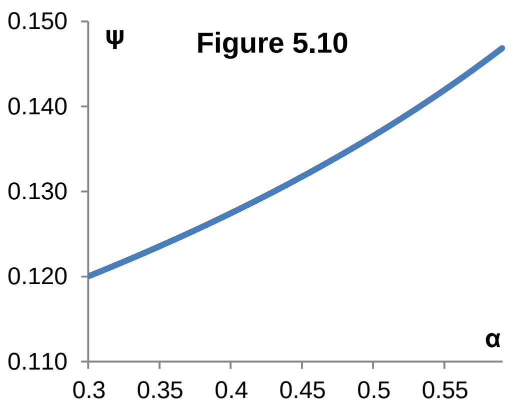
With the parameters provided in Table 5.5, the multiplier ψ receives the value of 0.1365 in the benchmark model. This means that a 1% depreciation in the RER leads to an increase of 0.1365% in the rate of capital accumulation. The dependence of the multiplier ψ on the model parameters is illustrated in Figures 5.8-5.13.

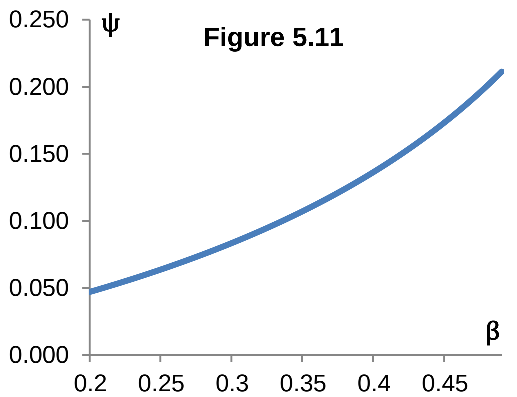
Similar to the calibration model for the case of a constant returns to scale tradables production function, there a positive relationship between the capital depreciation rate φ and the magnitude of the investment enhancing effect of an RER depreciation (see Figure 5.8). However, while the relationship between φ and the multiplier ζ has a convex upward shape, the relationship between φ and the multiplier ψ is closer to linear. The value of ψ appears to be moderately sensitive to the assigned value of φ. An increase of 10% in the value of φ from the benchmark case causes the multiplier ψ to increase by 9.84% while a decrease of 10% in the value of φcauses the multiplier ζ to decrease 9.85%.

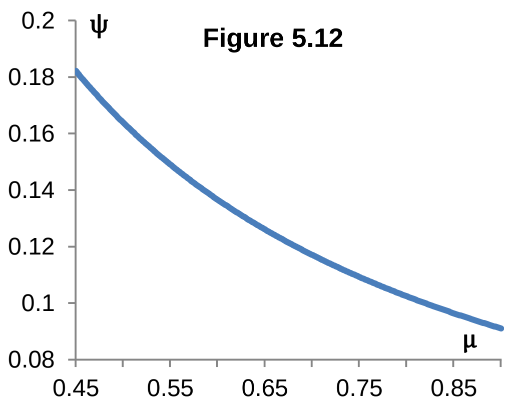
In Figure 5.9, the graph representing the relationship between the multiplier ψ and the subjective discount rate ϑ is a concave upward curve. Similar to the calibration model for the case of a constant returns to scale tradables production function, a higher subjective discount rate corresponds to a stronger investment enhancing effect of an RER depreciation. However, while an increase in the subjective discount rate causes the slope of the multiplier ζ to increase in the previous calibration model with a constant returns to scale tradables production function, it causes the slope of the multiplier ψ to decrease in this calibration model. In addition, sensitivity analysis indicates that the value of ψ is insensitive to the selection of the subjective discount rate. An increase of 10% in the subjective discount rate from the benchmark value

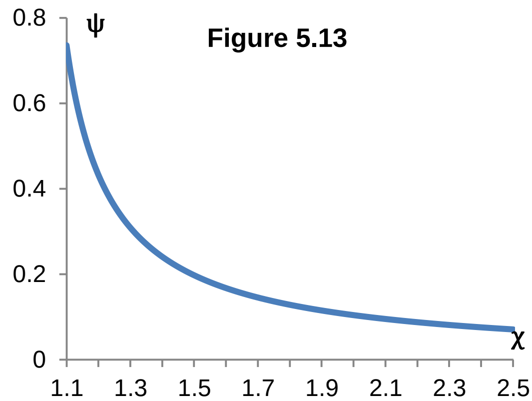












Source: *The author*

Figure 5.8: The depreciation rate and the multiplier ψ

Figure 5.9: The subjective discount rate and the multiplier ψ

Figure 5.10: The exponent of capital and the multiplier ψ

Figure 5.11: The exponent of labour and the multiplier ψ

Figure 5.12: The capital stock and the multiplier ψ

Figure 5.13: The investment cost function and the multiplier ψ

causes the multiplier ψ to increase 0.16% while a decrease of 10% in the capital depreciation rate causes the multiplier ψ to decrease 0.15%.

Figure 5.10 shows the negative relationship between the multiplier ψ and the exponent of capital in the tradables production function. This relationship has a convex upward shape and the slope of the curve increases as α increases. The magnitude of the investment enhancing effect of an RER depreciation appears to be insensitive to the selected value of the exponent of capital in the tradables production function. An increase of 10% in the value of α from the benchmark value causes the multiplier ψ to increase 3.96% while a decrease of 10% in the value of α makes the multiplier ψ decrease by 3.51%.

As shown in Figure 5.11, the exponent of labour in the tradables production function has a negative relationship with the multiplier ψ. ψ is a convex decreasing function of β. However, in contrast to the exponent of capital in the tradables production function, the selected value of the exponent of labour in the tradables production function largely affects the value of the multiplier ψ. The sensitivity analysis shows that an increase of 10% in the value of β from the benchmark value causes the multiplier ψ to increase 21.13% while a decrease of 10% in the value of α from the benchmark value causes the multiplier ψ to decrease 17.52%.

Similar to the calibration model for a constant returns to scale tradable production function, it is found in the model for a decreasing returns to scale tradable production function that the investment enhancing effect of an RER depreciation becomes larger as an economy moves far from the steady state. Figure 5.12 shows that the lower the ratio of the capital stock to the steady state level, the higher the value of the multiplier ψ. The value of ψ is moderately sensitive to the selected value of μ. A decrease of 10% in the value of μ from the benchmark value leads to an 11.1% increase in the value ofψ, and an increase of 10% in the value of μ causes the multiplier ψ to decrease 9.1%.

Figure 5.13 represents the relationship between the multiplier ψ and the exponent in the investment cost function x. The graph has a convex downward shape and the value of the multiplier ψ becomes extremely large as x

approaches unity. The properties are similar to the calibration model for a constant returns to scale tradable production function. The value of the multiplier ψ is very sensitive to the selected value of x. A decrease of 10% in the value of x causes the multiplier ψ to increase 27.6% while an increase of 10% in the value of x causes the multiplier ψ to decrease 17.8%.

5.4 Conclusion

Chapter 5 focused on examining the magnitude of the investment enhancing effects caused by an RER depreciation. Based on the theoretical model developed in the Chapter 4, particular forms of production and investment cost functions were specified. In the first calibrated model, tradables production function was assumed to have a Cobb-Douglas constant returns to scale form. The investment cost function was assumed to consist of a linear component and a strictly convex component. Both components have polynomial functional forms. Under these assumptions on the function forms, it was possible to derive a close form solution of the dynamic system. The capital accumulation rate was expressed as a linear function of a percentage change in the RER. The model parameters were specified so that the artificial economy corresponded to middle-income developing countries. In the benchmark model, the investment enhancing effect of an RER depreciation were found to be moderate. A 1% RER depreciation corresponded to a 0.4444% increase in the capital accumulation rate. It was also found that the capital depreciation discount rate and the subjective discount rate positively affects the investment enhancing effect of RER depreciation whereas the capital income share, the initial level of capital stock, the exponent in the investment cost function and the marginal product of capital has negative effects. Also, the magnitude of the investment enhancing effect of RER depreciation was found to be highly sensitive to the selected values of the capital depreciation rate, the capital income share in the tradables sector and the exponent in the investment cost function; moderately sensitive to the ratio of the capital stock to the steady state level, and the marginal product of capital; and almost insensitive to the subjective discount rate.

In the second calibrated model, the tradables production function was also assumed to follow a Cobb-Douglas form but with decreasing returns to scale. To make the model computable, the investment cost function was assumed to consist of a single polynomial and strictly convex component. Because a close form solution of the dynamic system cannot be derived as it could in the calibration model with a constant returns to scale tradables production function, the linearization approach was applied. The steady state was determined and then a linearized dynamics derived. The capital accumulation rate at a point in the vicinity of the steady state was expressed as an approximate function of percentage change in the RER. In order to reduce the measurement error caused by the linearization, the artificial economy was specified at a higher level of economic development and the model parameters adjusted accordingly. In the benchmark model, a 1% RER depreciation causes a 0.1366% increase in the capital accumulation rate. The magnitude of the investment enhancing effect is substantially smaller than those in the calibration model with a constant returns to scale tradables production function. Similar to the calibration model for the case of a constant returns to scale tradables production function, the capital depreciation rate and the subjective discount rate positively affect the magnitude of the investment enhancing effect of an RER depreciation. Also, the magnitude of the investment enhancing effect of an RER depreciation has a positive correlation with the exponent of capital in the tradables production function while having negative correlations with the exponent of labour in the tradables production function, the exponent of investment cost function, and the ratio of the capital stock to the steady state level. The calibrated result seems to be highly sensitive to the selected values of exponent of labour in the tradables production function, the exponent in the investment cost function, and the exponent of labour in the tradables production function. However, it is moderately sensitive to the selected values of the capital depreciation rate and the ratio of the capital stock to the steady state level, and relatively less sensitive to the selected values of the subjective discount rate and the exponent of capital in the tradables production function.

In order to be consistent with the theoretical framework provided in the Chapter 4, the calibration models in this chapter employed univariate investment cost functions. However, it should be noted that a multivariate investment cost function is more popular in the literature. In these, investment cost is a function of investment level and capital stock. In order to demonstrate the role of capital stock in determining the investment cost, the adjustment cost is often incorporated as a component of an investment function(for example, see Barro & Martin, 1995; Shioji, 2001). In a further research, it could be interesting to carry out calibration in a theoretical model that assumes the existence of investment adjustment cost.

CHAPTER 6

THE REAL EXCHANGE RATE MISALIGNMENT IN EAST ASIAN ECONOMIES

6.1 Introduction

Chapter 6 plays a role as an introduction to the East Asian economies, which are the subject of the empirical analyses in following chapters. This chapter consists of three parts. The first part captures distinctive features of the economies in the region, especially focusing on the nine countries sampled in this study. It emphasises on the similarities of and economic linkages between the regional countries. In the second part, the empirical algorithm to estimate the RER misalignment indices is described. This study estimates the RER misalignment by using three different estimation models and two price indices to generate six alternative RER misalignment indices. The last section of this chapter provides discussion on the RER misalignment in the nine sampled East Asian countries.

6.2 An overview of East Asian economies

East Asia is often defined as comprising Japan and developing East Asia which includes: the ten members of the Association of Southeast Asian Nations (ASEAN) (Indonesia, Malaysia, Philippines, Singapore, Thailand, Vietnam, Cambodia, Myanmar, Brunei and Laos); the three newly industrialised economies (NIEs) of North Asia (Hong Kong, South Korea and Taiwan); and mainland China. Being located in the same geographic region these countries are influenced by strong cultural and economic interactions. The miracle of East Asia’s economic development, which has been continuous over recent decades, makes this region decouple from other parts of the world economy. Nevertheless, East Asia can also be considered as a set of countries diverse in terms of the levels of economic development, economic structures and political institutions (Katada, 2011).

Notably, the concept of developing East Asia is to draw a distinction between Japan and the remaining countries in the region rather than to describe precisely the level of economic development of these countries as some of them now have become industrial economies. Japan’s economy took off in the 1950s and enjoyed a rapid pace of economic growth for nearly two decades. It caught up with advanced economies such as the US and became a mature economy in the 1970s, after which. Japan’s economic growth rate has been slowing. This differentiates Japan from other East Asian countries, which experienced high economic growth rates until the 2000s.

Because the data provided for the empirical analyses in this thesis are mostly available from 1980 and Japan’s economy exhibits a diverse trend in the context of the whole East Asian region, Japan is excluded from the country sample. Moreover, Taiwan and some less developed East Asian countries including Myanmar, Cambodia, Brunei and Laos are also not included because data on these countries is either not available or insufficient for the purpose of empirical analysis.

There is large variation in the level of economic development across the East Asian region. Japan and four newly industrial countries (NICs): Hong Kong, South Korea, Singapore and Taiwan are high income countries, whereas three ASEAN countries: Cambodia, Myanmar and Laos remain as less developed countries with per capita income less than US$ 1,000 per year. The income gap is large even among the group of the six middle-income countries: Indonesia, Malaysia, the Philippines, Thailand, Vietnam and China. For example, Malaysia’s per capita income is more than 5 times higher than Vietnam.

Besides the span of levels of economic development, East Asian economies are also diverse in terms of demography and political institutions. Hong Kong and Singapore can be considered as highly condensed business hubs located in small areas of dense population. By contrast, China is the largest country in the region with an enormous population. Regarding the political institutions, the region houses both democratic and non-democratic countries. The roles of governments are dominant in the non-democratic countries like China and Vietnam, whereas market forces play a greater role in the democratic countries.

There is increasing interdependence among East Asian economies due to the process of international fragmentation-based production. Horizontal specialisation has broken up the production process into geographically different stages. The production of a product, especially manufacturing, is no longer contained inside the border of a country but is dismantled into separated components that are processed in different countries. The emergence of China as a global factory has strengthened this fragmentation trend.

The interdependence among East Asian economies is highlighted by the growing intra-regional trade relations in the region. The share of intra-regional non-oil trade in East Asia increased from 34.4% in the mid-1980s to 52.1% in the mid-1990s. This ratio remained stable until the mid- 2000s. Considering the disaggregate components of trade, while both intra-regional imports and exports shares demonstrated an increasing trend from the mid- 1980s to the mid- 1990s, the situation changed in the next decade. The intra-regional imports share increased from 55.7% in the mid- 1990s to 62.7% in the mid-2000s, whereas the intra-regional exports share decreased from 49.0% to 44.5%. This mismatch between intra-regional imports and exports is explained as the products are produced by increasingly fragmentation-based processes, while a heavy portion of final goods are consumed through extra-regional exports. Notably, the intra-regional trade share among East Asian economies is catching up to the figure for the EU-15 region where the developed economy members are highly integrated.

Table 6.1: A prospect of examined East Asian economies, 2013

	Population *(Million)*	**Land area** *(square km)*	**Population density** *(People per sq. km)*	**GDP growth rate** *(average 1981-2013, %)*	**GDP** *(current US$ Billions)*	**GDP per capita** *(current US$ Thousands)*	**Exports** *(%GDP)*	**Imports** *(%GDP)*
Indonesia	249.90	1,811,570	138	5.35	868.3	3,475	24	26
Malaysia	29.72	328,550	90	5.82	312.4	10,514	82	73
Philippines	98.39	298,170	330	3.34	272.0	2,765	28	32
Thailand	67.01	510,890	131	5.31	387.3	5,779	74	70
Hong Kong	7.19	1,050	6,845	4.74	274.0	38,124	230	229
South Korea	50.22	97,350	516	6.51	1.305	25,977	54	49
Singapore	5.40	700	7,713	6.63	297.9	55,182	191	168
China	1,357.58	9,388,211	145	9.87	9.240	6,807	26	24
Vietnam	89.71	310,070	289	6.42[a]	171.4	1,911	80	77

[a]: *1985-2013 average*

Source*: The World Bank DataBank*

Table 6.2: The intra-regional shares of non-oil trade (%)

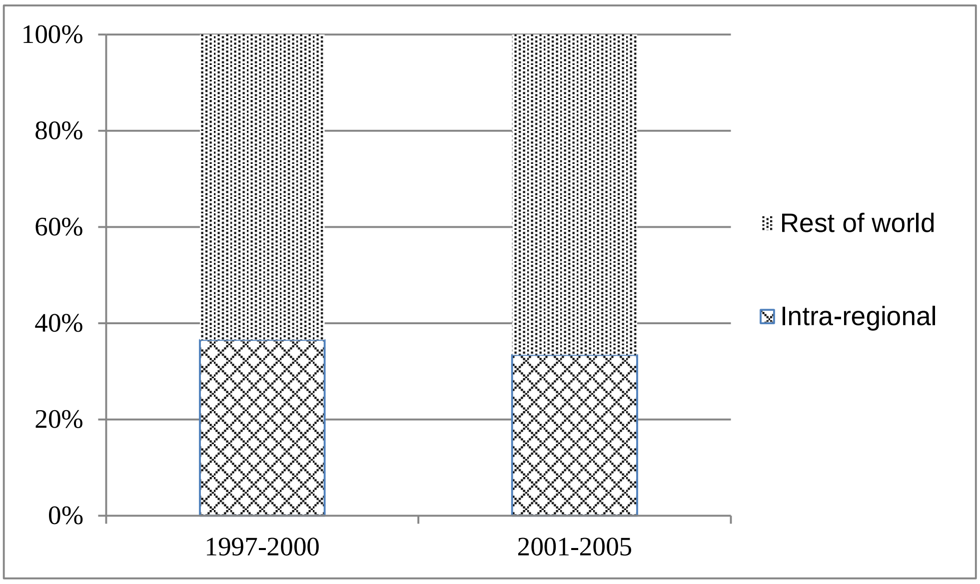
Item	East Asia	Developing East Asia	ASEAN	EU-15
Exports				
1986-1987	29.3	24.1	9.8	66.6
1994-1995	49.0	38.0	20.8	64.8
2006-2007	44.5	34.4	18.9	59.5
Imports				
1986-1987	41.5	24.6	8.6	66.3
1994-1995	55.7	36.4	16.6	63.9
2006-2007	62.7	47.2	22.8	58.0
Total trade (exports + imports)				
1986-1987	34.4	24.3	9.2	66.5
1994-1995	52.1	37.2	18.4	64.3
2006-2007	52.1	40.2	21.2	58.7

Notes: *Data are two-year averages*

Source*: Adapted from Prema-chandra and Kohpaiboon (2009)*

East Asian economies are also closely connected through financial linkages. Cross-border capital flows have significantly contributed to financial integration in the region and intra-regional portfolio investment has demonstrated a growing trend in the recent decades. The total intra-regional investment of eight East Asian countries in equity portfolio and debt securities has increased about four-fold from US$324.8 billion in 2001 to US$1320.33 billion in 2009 (Table 6.3). The intra-regional investment accounted for up to 24.9% of those countries' total asset holdings by 2009. The share of capital raised intra-regionally in these eight East Asian countries' total liabilities also demonstrated a rising trend over the period 2001-2009. The role of intra-regional investment is more obvious in terms of direct investment. As shown in Figure 6.1, developing East Asian countries' intra-regional FDI accounted for around 35% of total inflows on the average for the period 1997-2005.

Figure 6.1: Intra-regional FDI in developing East Asian countries



Source*: Adapted from R. S. Rajan (2008)*

Besides the trade and financial integration, which is mostly driven by market-forces, there are collective action programs and institutional integration promoted by the regional countries' governments. As well as the efficient operation of ASEAN, much effort has been put into developing an East Asian community though developing regional bodies. For instance, ASEAN Plus Three cooperation, which involves members of ASEAN and three countries: China, South Korea and Japan, was established in 1997. Moreover, the integration between East Asian countries is deepened through the cooperative organisations of the regional countries and outside partners such as the Asia–Pacific Economic Cooperation (APEC) and the East Asia Summit (EAS) process (or East Asia-16).

Those regional bodies have promoted a variety of co-operational activities to strengthen the linkages between member countries. These activities focus on two main areas: financial cooperation; and free trade area agreements. The financial cooperation includes developing a regional surveillance mechanism, e.g. ASEAN Surveillance Process, Executives' Meeting of East Asia–Pacific (EMEAP) Central Banks, and Manila Framework Group, to prevent potential financial crises. Regional countries have also established financial facilities to provide resources for member countries when needed such as the ASEAN Swap Arrangement, and Chiang Mai Initiative. The emergence of free trade area agreements between East Asian countries is a prominent feature in the regional cooperation. The pioneer free trade area agreement in the region was initiated in 1992 between ASEAN members. Subsequently, other East Asian countries have become involved in forms of the ASEAN+1 (ASEAN plus one country) free trade agreement, .e.g. ASEAN–China, ASEAN–Japan, and ASEAN–South Korea.

Table 6.3: Intra-regional portfolio investment

8 East Asian countries (EA8)	*2001*				*2006*				*2009*			
	Assets in		**Liabilities from**		**Assets in**		**Liabilities from**		**Assets in**		**Liabilities from**	
	EA8	***Total***	***EA8***	***Total***	***EA8***	***Total***	***EA8***	***Total***	***EA8***	***Total***	***EA8***	***Total***
China	Na	na	10.03	20.26	na	na	115.70	281.64	na	na	181.57	406.99
Hong Kong	23.1	205.6	5.5	96.7	139.8	592.5	28.9	233.7	189.2	810.8	26.7	254.7
Indonesia	0.2	0.7	1.0	5.6	0.3	1.5	5.7	38.9	0.7	4.7	11.4	71.5
South Korea	1.5	8.0	8.3	76.8	9.8	83.5	32.8	280.5	22.3	102.4	59.0	309.0
Malaysia	0.8	2.3	9.8	22.6	2.7	7.2	18.3	59.4	9.2	27.1	17.1	69.5
Philippines	0.1	2.1	2.6	12.7	1.3	7.2	2.0	30.3	0.3	5.0	3.4	29.0
Singapore	22.0	105.2	3.5	50.7	74.3	244.6	12.5	126.1	91.1	347.0	12.3	132.8
Thailand	0.3	0.8	3.7	12.0	1.0	5.1	5.9	37.8	16.1	23.4	6.1	49.2
Total	***48.0***	***324.8***	***34.5***	***277.1***	***229.1***	***941.6***	***106.0***	***806.6***	***328.8***	***1320.3***	***135.9***	***915.8***
%	*14.8%*	*100%*	*12.4%*	*100%*	*24.3%*	*100%*	*13.1%*	*100%*	*24.9%*	*100%*	*14.8%*	*100%*

Source*: Adapted from Kim and Lee (2012)*

6.3 The RER misalignment estimation methods

This study applies the reduced equation approach to estimate the RER misalignment indices. This approach is especially popular in studies of developing countries where the trade elasticities and other simulation parameters as required by other approaches, such as partial equilibrium or general equilibrium, are often not available or not reliably estimated. An obvious advantage of the reduced equation approach is its simplicity. The underlying idea of this method, first introduced by Edwards (1988), is to identify a set of fundamental factors determining the ERER. The RER is then regressed on those real factors and the predicted value of the regression model is used as the ERER.

To avoid the arbitrariness in selecting a price index, which influences the estimated value of the RER misalignment, both consumer price index (CPI) and GDP deflator (DFL), for which data are available over the examined sample, are used in this study. Also, different sets of the fundamental factors are specified, resulting in a number of alternative RER misalignment indices. This strategy improves the comprehensiveness of the empirical analysis and the robustness of empirical results, and minimises concern about any biased results caused by model misspecification errors.

The real exchange rate misalignment indices are computed in three steps.

6.3.1 The RER estimation methods

First, a real exchange rate (RER) is estimated by adjusting the nominal exchange rate (NER) measured as the number of national currency units per US dollar from a price index:

$$RER^{C}{}_{it} = \frac{NER_{it}}{NER_i^*}\frac{CPI_i^*}{CPI_{it}}\frac{CPI_{US,t}}{CPI_{US}^*} \tag{6.1}$$

$$RER^{D}{}_{it} = \frac{NER_{it}}{NER_{i}^{*}} \frac{DFL_{i}^{*}}{DFL_{it}} \frac{DFL_{US,t}}{DFL_{US}^{*}} \quad (6.2)$$

where i and t are country and time indices, respectively. The asterisk indicates values at the base year. RER^{C} and RER^{D} are respectively the RER calculated by using consumer price index (CPI) and GDP deflator (DFL).

6.3.2 The ERER estimation methods

In the second step, the ERER level is estimated by specifying an econometric model that includes fundamental factors expected to influence the behaviour of the RER in the medium term.

In the simplest form, the ERER is derived by adjusting the RER from the Balassa-Samuelson effect. The productivity is a single fundamental factor in this ERER model. This ERER model specification was introduced by Dollar (1992) and then was popularly applied in empirical studies (e.g. Acemoglu et al., 2003; Aguirre & Calderon, 2005; Gala, 2008; Rodrik, 2008). This study uses a country's relative income to the US to proxy for the productivity variable, instead of using the absolute level of income as in previous studies. The advantage of the relative income is that it better captures the Balassa-Samuelson effect, which formulates the effect of the divergence in productivity growth rate between two countries on the RER. When the income of the peer country, e.g. the US in this case, is not constant, a change in a country's income level might not precisely proxy for the divergence in the productivity growth rate, at least in terms of magnitude. The first and second estimates of the ERER, $ERER^{1}$ and $ERER^{2}$, are derived by the following equations:

$$RER^{C}{}_{it} = \alpha_0 + \alpha_1 GDPHR_{it} + \gamma T + \mu_{it} \quad (6.3)$$

$$ERER1_{it} = \widehat{\alpha_0} + \widehat{\alpha_1} GDPHR_{it} + \hat{\gamma} T \quad (6.4)$$

and:

$$RER^{D}{}_{it} = \beta_0 + \beta_1 GDPHR_{it} + \theta T + \mu_{it} \tag{6.5}$$

$$ERER2_{it} = \widehat{\beta_0} + \widehat{\beta_1} GDPHR_{it} + \hat{\theta} T \tag{6.6}$$

where $GDPHR$ is the ratio of a country's per capita income to the US per capita income; T are a set of time dummies; and α, β, γ and θ are coefficients or a vector of coefficients. A hat over coefficients indicates the estimated values.

The second form of the ERER model is based on the model developed by Elbadawi et al. (2008). This model takes into account additional fundamentals other than the productivity factor as reflected in the following equations:

$$RER^{C}{}_{it} = \alpha_0 + \alpha_1 GDPHR_{it} + \alpha_2 TOT_{it} + \alpha_3 OPN_{it} + \alpha_4 FDI_{it} + \alpha_5 FIC_{it} + \gamma T + u_{it} \tag{6.7}$$

$$ERER3_{it} = \widehat{\alpha_0} + \widehat{\alpha_1} GDPHR_{it} + \widehat{\alpha_2} TOT_{it} + \widehat{\alpha_3} OPN_{it} + \widehat{\alpha_4} FDI_{it} + \widehat{\alpha_5} FIC_{it} + \hat{\gamma} T \tag{6.8}$$

and:

$$RER^{D}{}_{it} = \beta_0 + \beta_1 GDPHR_{it} + \beta_2 TOT_{it} + \beta_3 OPN_{it} + \beta_4 FDI_{it} + \beta_5 FIC_{it} + \theta T + u_{it} \tag{6.9}$$

$$ERER4_{it} = \widehat{\beta_0} + \widehat{\beta_1} GDPHR_{it} + \widehat{\beta_2} TOT_{it} + \widehat{\beta_3} OPN_{it} + \widehat{\beta_4} FDI_{it} + \widehat{\beta_5} FIC_{it} + \hat{\theta} T \tag{6.10}$$

where TOT is the terms of trade; OPN is the degree of openness measured as the ratio of trade volume to GDP; FDI is the ratio of foreign direct investment inflows to GDP; and FIC is the ratio of foreign income to GDP.

Based on the argument that the RER misalignment is the result of the short-run price rigidity, Razin and Collins (1999) developed a simple expansion of IS-LM model to identify the determinants of the ERER. It was shown that the factors affecting the ERER not only include longer-run fundamentals, e.g.

components of output supply, aggregate demand, and trade balances, but also short-run shocks. The Razin and Collins (1999)'s model is applied for the examined country sample as the following equations:

$$\begin{aligned} RER^{C}{}_{it} = \alpha_0 + \alpha_1 GDPHR_{it} + \alpha_2 TOT^{T}{}_{it} + \alpha_3 IRS^{T}{}_{it} + \alpha_4 FDI^{T}{}_{it} \\ + \alpha_5 FIC^{T}{}_{it} + \alpha_6 DMG^{T}{}_{it} + \alpha_7 GDPHR^{H}{}_{it} \\ + \alpha_8 ABS^{H}{}_{it} + \alpha_9 LMS^{H}{}_{it} + \gamma T + u_{it} \end{aligned} \tag{6.11}$$

$$\begin{aligned} ERER5_{it} = \widehat{\alpha_0} + \widehat{\alpha_1} GDPHR_{it} + \widehat{\alpha_2} TOT^{T}{}_{it} + \widehat{\alpha_3} IRS^{T}{}_{it} \\ + \widehat{\alpha_4} FDI^{T}{}_{it} + \widehat{\alpha_5} FIC^{T}{}_{it} + \widehat{\alpha_6} DMG^{T}{}_{it} \\ + \widehat{\alpha_7} GDPHR^{H}{}_{it} + \widehat{\alpha}\ ABS^{H}{}_{it} + \widehat{\alpha}\ LMS^{H}{}_{it} + \hat{\gamma} T \end{aligned} \tag{6.12}$$

and:

$$\begin{aligned} RER^{D}{}_{it} = \beta_0 + \beta_1 GDPHR_{it} + \beta_2 TOT^{T}{}_{it} + \beta_3 IRS^{T}{}_{it} + \beta_4 FDI^{T}{}_{it} \\ + FIC^{T}{}_{it} + \beta_6 DMG^{T}{}_{it} + \beta_7 GDPHR^{H}{}_{it} \\ + \beta_8 ABS^{H}{}_{it} + \beta_9 LMS^{H}{}_{it} + \theta T + u_{it} \end{aligned} \tag{6.13}$$

$$\begin{aligned} ERER6_{it} = \widehat{\beta_0} + \widehat{\beta_1} GDPHR_{it} + \widehat{\beta_2} TOT^{T}{}_{it} + \widehat{\beta_3} IRS^{T}{}_{it} + \widehat{\beta_4} FDI^{T}{}_{it} \\ + \widehat{\beta_5} FIC^{T}{}_{it} + \widehat{\beta_6} DMG^{T}{}_{it} + \widehat{\beta_7} GDPHR^{H}{}_{it} \\ + \widehat{\beta_8} ABS^{H}{}_{it} + \widehat{\beta_9} LMS^{H}{}_{it} + \hat{\theta} T \end{aligned} \tag{6.14}$$

where TOT^T , IRS^T, FDI^T, FIC^T and DMG^T are the Hodrick–Prescott high-pass filter (Hodrick & Prescott, 1997) trend components of: terms of trade, the ratio of international reserve to GDP, the ratio of foreign direct investment inflows to GDP, the ratio of foreign income to GDP, and the gap between the broad money supply (M2) growth rate and the GDP growth rate, respectively. They and $GDPHR$ are fundamental factors influencing the out supply, aggregate demand and trade balance. $GDPHR^H$, ABS^H and LMS^H are the Hodrick–Prescott high-pass filter cyclical components of: the relative GDP per capita of a country and the US, the domestic absorption ratio measured as the ratio of GDP minus net export to GDP, and the broad money supply (M2) in terms of natural logarithm, respectively. These cyclical components represent the short-run shocks to output, absorption and money supply.

6.3.3 The RER misalignment index

Finally, the ratio of the RER to the estimated ERER is used as an index of the RER misalignment. There are six alternative indices of the RER misalignment associated with six estimates of the ERER.

$$MIS1_{it} = \frac{RER^{C}{}_{it}}{ERER1_{it}} \tag{6.15}$$

$$MIS2_{it} = \frac{RER^{D}{}_{it}}{ERER2_{it}} \tag{6.16}$$

$$MIS3_{it} = \frac{RER^{C}{}_{it}}{ERER3_{it}} \tag{6.17}$$

$$MIS4_{it} = \frac{RER^{D}{}_{it}}{ERER4_{it}} \tag{6.18}$$

$$MIS5_{it} = \frac{RER^{C}{}_{it}}{ERER5_{it}} \tag{6.19}$$

$$MIS6_{it} = \frac{RER^{D}{}_{it}}{ERER6_{it}} \tag{6.20}$$

A higher value of a RER misalignment index is associated with a more depreciated RER. The RER could be considered to be undervalued or overvalued if the RER misalignment is greater or less than unity, respectively.

6.4 The RER misalignment estimation

6.4.1 Data

Data used for estimating the RER misalignment indices are all sourced from the The World Bank DataBank. This database is updated regularly and is available via the website http://databank.worldbank.org. Table 6.4 presents the names and definitions of variables used to estimate the RER misalignment indices.

Table 6.4: Input data for estimating the RER misalignment indices

Variable	Definition
NER	Official exchange rate (LCU per US$, period average)
GDP	Gross domestic product (constant 2005 and current US$)
$GDPH$	GDP per capita (constant 2005 US$)
CPI	Consumer price index (year 2005: 100)
INF	GDP deflator (base year varies by country)
TOT	Net barter terms of trade index (year 2000: 100)
IM	Imports of good and service (constant 2005 US$)
EX	Exports of good and service (constant 2005 US$)
FDI	Foreign direct investment net inflows (current US$)
FIC	Net income from abroad (current US$)
IRS	Total reserve, include gold (current US$)
$M2$	Money and quasi money (M2) (current local currency)

Source*: The author*

6.4.2 RER misalignment estimation results

The number of estimated RER misalignment observations is different among countries and methods applied (Table 6.5). $MIS1$ and $MIS2$, which are estimated by a simple model using only data on outputs and price indices, are the longest estimated RER misalignment indices series. By contrast, a number of observations of $MIS3$, $MIS4$, $MIS5$ and $MIS6$ series are cut off because additional variables other than outputs and price indices, which are required to estimate the ERER, are not available with a long range of data.

Table 6.5: RER misalignment estimation periods

	$MIS1$	$MIS2$	$MIS3$	$MIS4$	$MIS5$	$MIS6$
Indonesia	1967-2012	1967-2012	1981-2011	1981-2011	1981-2011	1981-2011
Malaysia	1960-2012	1960-2012	1980-2011	1980-2011	1980-2011	1980-2011
Philippines	1960-2012	1960-2012	1980-2011	1980-2011	1980-2011	1980-2011
Thailand	1965-2012	1965-2012	1980-2011	1980-2011	1980-2011	1980-2011
Hong Kong	1981-2012	1965-2012	1999-2011	1999-2011	1999-2011	1999-2011
South Korea	1966-2012	1960-2012	1980-2011	1980-2011	1980-2011	1980-2011
Singapore	1960-2012	1960-2012	1980-2011	1980-2011	1980-2011	1980-2011
China	1986-2012	1960-2012	1986-2011	1982-2011	1986-2011	1982-2011
Vietnam	1995-2012	1986-2012	2000-2011	2000-2011	2000-2011	2000-2011

Source*: The author*

Alternative RER misalignment indices are shown to be highly correlated, especially among indices that are derived from a same price index (Table 6.6). For example, the correlation between $MIS1$ and $MIS3$ is up to 0.9616, and the correlation between $MIS2$ and $MIS4$ is 0.8490. Correlations between two RER misalignment indices derived from a same price index are no less than 0.7500. Correlations between two RER misalignment indices derived from a same method but different price indices are also high. The correlation between $MIS1$ and $MIS2$ is the lowest of this class and equals 0.6938. The correlations between $MIS3$ and $MIS4$, and between $MIS5$ and $MIS6$ are 0.7647 and 0.7777, respectively. The lowest correlations are among RER misalignment indices derived from different methods and different price indices. The lowest of all is the correlation between $MIS2$ and $MIS5$.

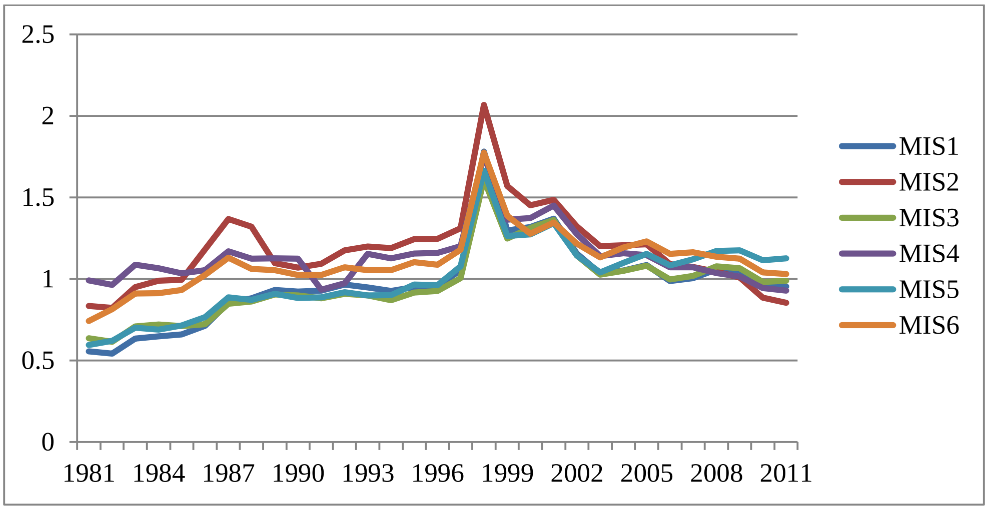
Table 6.6: Correlation among alternative RER misalignment indices

	$MIS1$	$MIS2$	$MIS3$	$MIS4$	$MIS5$	$MIS6$
$MIS1$	*1.0000*					
$MIS2$	*0.6938*	*1.0000*				
$MIS3$	*0.9616*	*0.6633*	*1.000*			
$MIS4$	*0.7325*	*0.8490*	*0.7647*	*1.0000*		
$MIS5$	*0.7915*	*0.5895*	*0.8053*	*0.5975*	*1.000*	
$MIS6$	*0.6296*	*0.7599*	*0.6471*	*0.7572*	*0.7777*	*1.000*

Source*: The author*

Indonesia's RER misalignment demonstrates significant fluctuation over the period 1981-2011 (Figure 6.2). All of the RER misalignment indices show a clear trend of depreciation over the period from the early 1980s until the Asian financial crisis (1997-1998). At the time of the crisis, the free floating exchange rate regime was applied and the nominal exchange rate of domestic currency against US$ dropped by more than 80%. This plunge caused a dramatic depreciation in the RER. In the post-crisis period, the RER misalignment moved toward the equilibrium level.

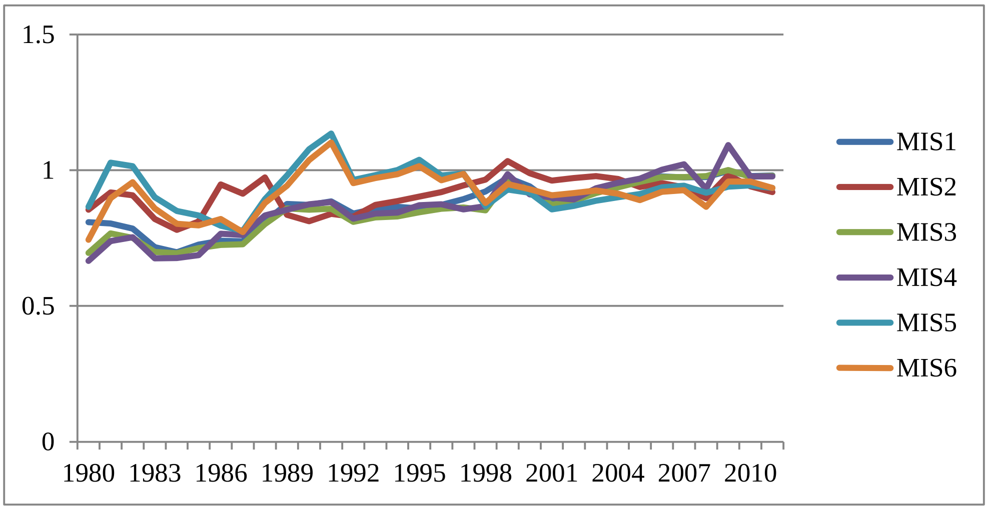
Figure 6.2: The RER misalignment in Indonesia, 1981-2011



Source*: The author*

By contrast, three other countries also hit by the Asian financial crisis, comprising Malaysia, the Philippines and Thailand, did not suffer large fluctuations in the RER misalignment level. The RER misalignment in Malaysia (Figure 6.3) demonstrates a gradual depreciation trend over the period 1980-2011. The RER appears to be overvalued in the 1980s and then moved toward the equilibrium level. Notably, the RER misalignment indices estimated by the Razin and Collins (1999)'s model, $MIS5$ and $MIS6$, are more fluctuating and exhibit an opposite trend to other indices during the Asian financial crisis period. $MIS5$ and $MIS6$ indicate an appreciation in the Malaysian currency during the crisis, while other indices show a depreciation. In the case of the Philippines, the RER misalignment indices move closely together (Figure 6.4). It can be seen that the RER misalignment level is stable in 1980s and then slightly appreciates from the beginning of the 1990s to the Asian financial crisis. After the crisis, the RER misalignment follows a depreciation trend. In the case of Thailand (Figure 6.5), only $MIS1$ and $MIS2$ demonstrate a depreciation in the RER over the period of the Asian financial crisis while other RER misalignment indices show that the RER appreciated in year 1998 and depreciated after that.

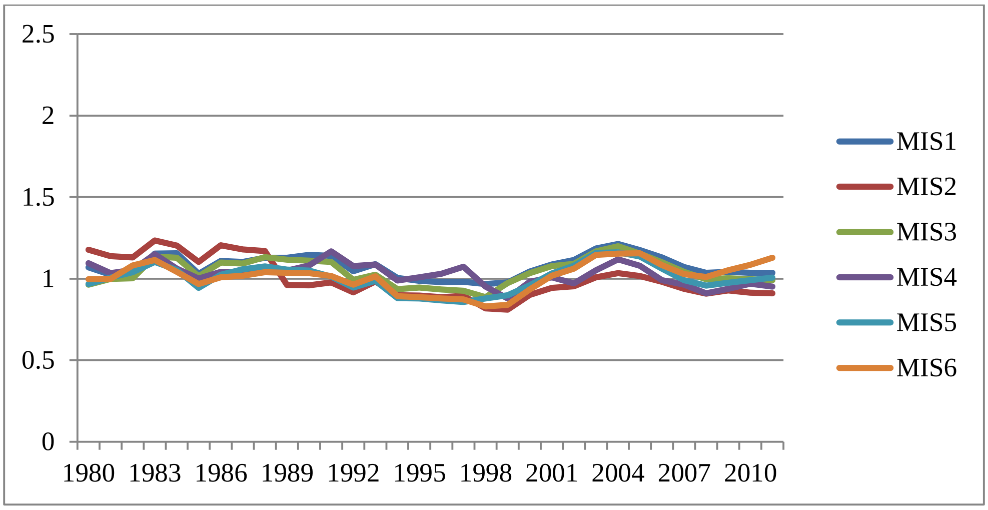
Figure 6.3: The RER misalignment in Malaysia, 1980-2011



Source*: The author*

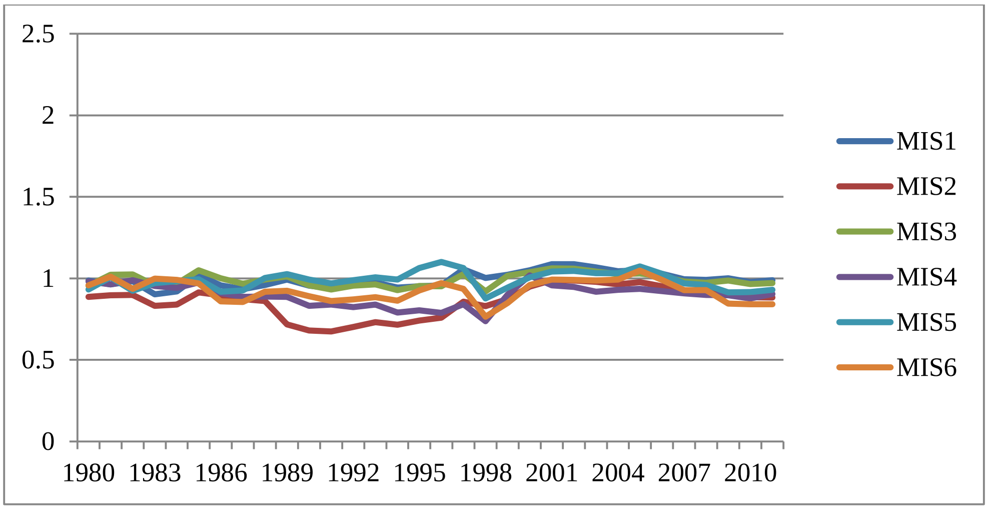
It should be noted that all of these countries: Indonesia, Malaysia, the Philippines and Thailand, suffered large devaluation in the nominal exchange rate in the Asian financial crisis period. This plunge in the nominal rate overwhelmed the deflation in the price level and the collapse of output. As a result, the RER misalignment indices estimated by the simple Dollar (1992)'s method, by which the ERER is derived by adjusting the RER from only the Samuelsson-Balassa effect, must reflect a depreciation. By contrast, when other fundamental factors are considered in the ERER equation, a large devaluation in the nominal exchange rate does not necessarily lead to a depreciation in the RER. For example, such devaluation could be a consistent response to a massive outflow of capital. It explains why $MIS1$ and $MIS2$ always demonstrate a depreciation in the RER in those countries in the Asian financial crisis period but other RER misalignment indices do not.

Figure 6.4: The RER misalignment in Philippines, 1980-2011



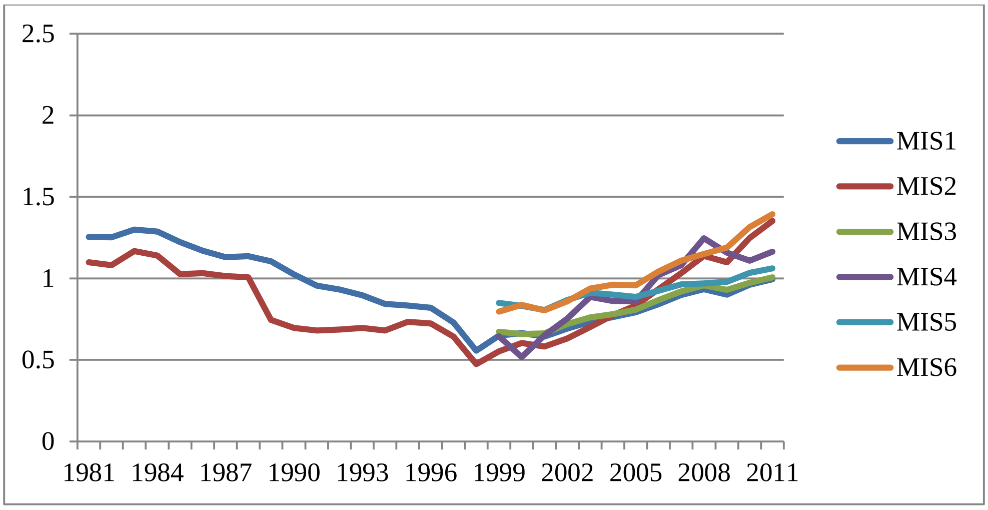
Source*: The author*

Figure 6.5: The RER misalignment in Thailand, 1980-2011



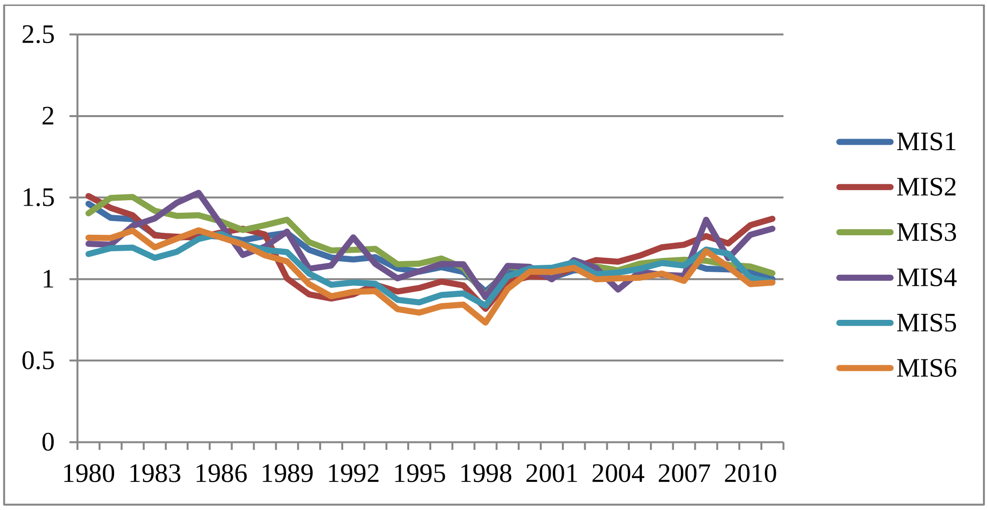
Source*: The author*

Figure 6.6: The RER misalignment in Hong Kong, 1981-2011



Source*: The author*

Figure 6.7: The RER misalignment in Singapore, 1981-2011

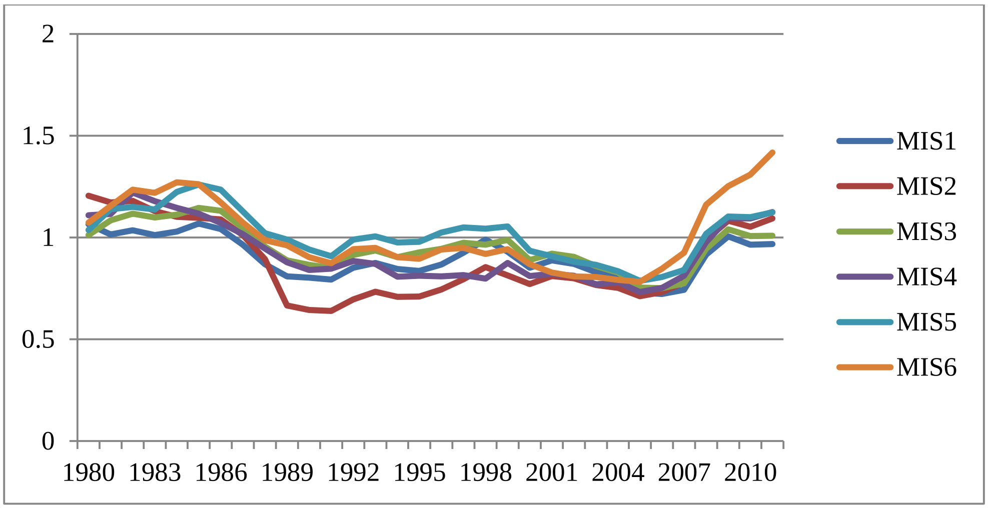


Source*: The author*

The RER in Hong Kong (Figure 6.6) follows two opposite trends over the periods before and after the Asian financial crisis. The RER misalignment indices persistently decreased from the 1980s to the mid-1990s. The appreciation of the RER misalignment indices was even more rapid over the period right before the crisis. Over the post-crisis period, the RER turned to follow a depreciated trend. A similar pattern is found in Singapore (Figure 6.7) as the RER misalignment decreased over the pre-crisis period and increased over the pos-crisis period. Moreover, $MIS4$ particularly appears to be more fluctuating than other RER misalignment indices in the case of Singapore. In some periods, $MIS4$ does not follow the overall trend. For example, $MIS4$ moved upward in the first half of the 1980s while other RER misalignment indices moved downward.

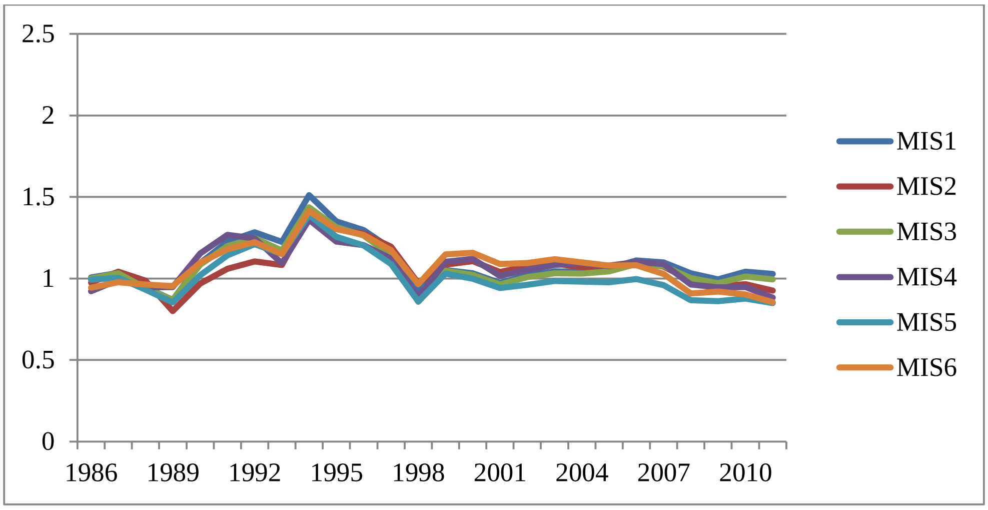
The RER in South Korea (Figure 6.8) largely appreciated in the second half of the 1980s and then slightly depreciated in the 1990s until the Asian financial crisis. Subsequently, the RER misalignment moved slightly down in the post-crisis period. When the global financial crisis occurred in 2007, the RER in South Korea started depreciating rapidly. In China, the RER misalignment indices (Figure 6.9) went up from the mid-1980s to the mid-1990s and then went down until the occurrence of the Asian financial crisis. At the time of the crisis, there was a large fluctuation in the RER misalignment level as it firstly went down and then recovered. After that, it was stable for the first half of the 2000s and then gradually decreased in the second half of the decade. In Vietnam, the RER fluctuated extremely in the late 1980s and beginning of the 1990s (Figure 6.10). The transition from a central planning to a market-oriented economy caused severe shocks to Vietnam in the second half of the 1980s. The official exchange rate was extensively devalued to approach the market rate. This resulted in a sharp increase in the RER misalignment in the late 1980s. Consequently, the RER misalignment followed a decreasing trend until the Asian financial crisis. In the aftermath of the crisis, the RER misalignment steadily went down.

Figure 6.8: The RER misalignment in South Korea, 1981-2011



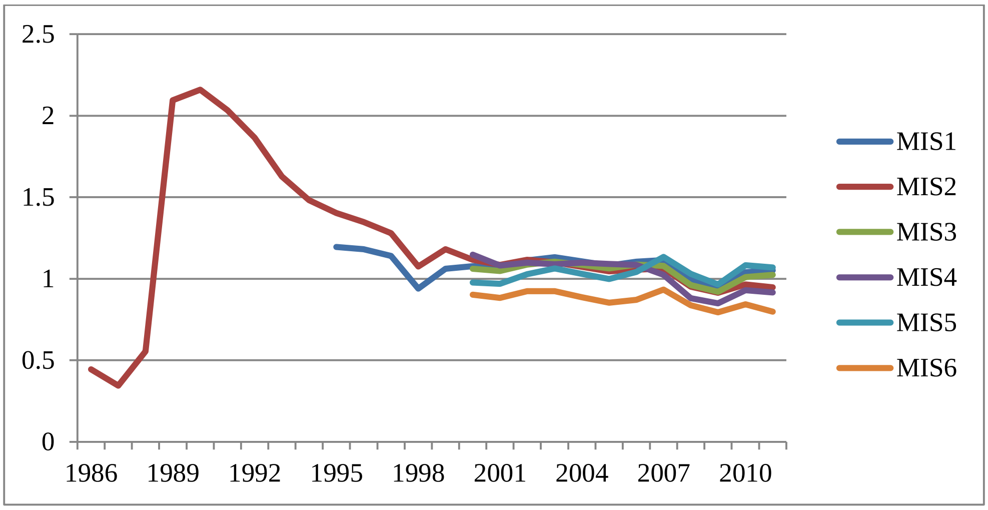
Source*: The author*

Figure 6.9: The RER misalignment in China, 1986-2011



Source*: The author*

Figure 6.10: The RER misalignment in Vietnam, 1986-2011



Source*: The author*

6.5 Conclusion

The overview of the countries in the East Asian region focussed on the nine countries sampled in the empirical analysis in this thesis. The sampled East Asian countries are not only closed in terms of geography but also share other common features. They have outperformed the other parts of the world economy and attained high rates of economic growth for more than the recent three decades. Moreover, there are strong intra-regional trade and financial linkages between these countries. The governments of East Asian countries' essentially contribute to institutional integration by establishing and encouraging the operation of the regional bodies. These features define East Asian countries as a distinct community from other parts of the world economy. Nevertheless, it is noteworthy that East Asian countries are also remarkably diverse with respect to the development level, demographic factors and the political system.

Chapter 6 describes the empirical algorithm to estimate the RER misalignment indices for sampled countries and provides discussion on the RER misalignment in the nine sampled East Asian countries.

In this study, two alternative price indices, CPI and GDP deflator, are used to estimate the RER. This combines with three methods to estimate the ERER and then results in a total of six alternative indices of the RER misalignment. The first method simply derived the ERER from adjusting the RER for the Balassa and Samuelsson effect. The other two methods are more complicated as they incorporate other fundamental factors into the ERER models. Nevertheless, the estimated RER misalignment indices are highly correlated to each other, especially between indices estimated by using the same method or the same price index.

CHAPTER 7

THE REAL EXCHANGE RATE MISALIGNMENT AND ECONOMIC GROWTH IN EAST ASIAN ECONOMIES: THE ROLE OF FINANCIAL INTEGRATION

7.1 Introduction

Based on the neoclassical view, the manifesto of Washington-based institutions for developing countries, known as the Washington consensus, proposed that an equilibrium real exchange rate to promote growth is constrained by the supply-side factor (Williamson, 1990). While there is a consensus that developing countries should avoid overvaluation, the influence of undervaluation on economic growth is the subject of growing debate.

The relationship between undervaluation and economic growth has been examined in a large number of empirical studies. A majority of empirical studies seem to suggest that undervaluation has growth-enhancing effects (Bereau et al., 2012; Bhalla, 2007; Bleaney & Greenaway, 2001; Gala, 2008; Hausmann et al., 2005; Prasad et al., 2007; Razin & Collins, 1999) and these effects tend to be more significant in developing countries (Razmi et al., 2012; Rodrik, 2008; Vieira & MacDonald, 2012). However, counterevidence can be found in recent studies that demonstrate the importance of revealing the channels of influence of undervaluation (Nouira & Sekkat, 2012; Schroder, 2013).

Despite plentiful evidence supporting a correlation between undervaluation and economic growth, understanding of the nature of this relationship is still limited. Hypotheses are mostly focused on the role of undervaluation in supporting the tradable sector (Prasad et al., 2007; Rodrik, 2008) and in stimulating capital accumulation (Gala, 2008; Gluzmann et al., 2012; Ibarra, 2011; Razmi et al., 2012). Gluzmann et al. (2012) also found that undervaluation affects saving and employment. Porcile and Lima (2010) offer a balance-of-payments constrained macrodynamic model that explains the impact of undervaluation through both channels. Devaluation increases a country's exports and releases constraints on the balance of payments. This eventually leads to a higher level of investment.

This study examines the role of financial integration in determining the relationship between the real exchange rate (RER) and economic growth. Based on arguments about the capital accumulation channel, it could be hypothesised that the growth-enhancing effect of a competitive real exchange rate would be more robust in economies with a low level of financial integration that are subject to balance of payments constraints. This research used a sample consisting of nine East Asian countries, namely: Hong Kong, South Korea, Singapore, Malaysia, Indonesia, Philippines, Thailand, China and Vietnam. These countries have attained a high economic growth rate over recent decades and share common features in the process of economic development, such as an export-led growth strategy with a high degree of openness, and a focus on the manufacturing and tradable goods sectors. The RER, therefore, could be important to economic growth due to these characteristics.

This remainder of this chapter is set out as follows. Section 7.2 describes the empirical models used to test the underlined hypothesis. Section 7.3 presents an estimation strategy, regression results and implications. Section 7.4 provides the conclusion.

7.2 Methodology and data

7.2.1 Growth model specification

To examine the influence of financial integration on the relationship between RER misalignment and economic growth, a growth model was specified in which RER misalignment and its interaction term with financial integration were used as explanatory variables. The general form of the growth model is specified as:

$$GDPG_{it} = \beta_0 + \sum_{p=1}^{m} \beta_1 GDPG_{i,t-p} + \sum_{p=1}^{n} \beta_2 MIS_{i,t-p} + \sum_{p=1}^{n} \beta_3 MIS_{i,t-p} * F_{i,t-p} + \sum_{p=1}^{n} \beta_3 F_{i,t-1} + \sum_{p=1}^{l} \theta C_{i,t-p} + u_{it} \tag{7.1}$$

where $GDPG$ is the per capita income growth rate; F is a variable proxying for a country's degree of financial integration; C is a vector of control variables including the share of government spending in GDP (GOV), inflation (INF) and the ratio of gross fixed capital formation in GDP (FCF); and MIS is a RER misalignment index estimated in Chapter 5. Alternative RER misalignment indices are used to improve the robustness of empirical evidence. Notably, the contemporary terms of the explanatory variables were dropped to avoid the endogeneity problem.

Based on the availability of data on the sampled countries, this research employed three indicators as alternative proxies for the degree of financial integration: the inflows of foreign direct investment (FDI) measured as percentage of GDP; a financial openness indicator (FOP) constructed by the method suggested by Chinn and Ito (2008); and dummy variables (H and L), which categorised the sampled countries subjectively according to the degree of financial integration. H equals 1 in the case of newly industrialised countries (Hong Kong, South Korea and Singapore) which were considered to be highly financial integrated; H equals 0 otherwise. Similarly, L equals 1 in case of transitional economies (China and Vietnam) which are characterised by lower degrees of financial integration; L equals 0 otherwise.

Chinn and Ito (2008)'s financial openness indicator (FOP) is constructed by using data on cross-border financial transactions provided by the IMF's Annual Report on Exchange Arrangements and Exchange Restrictions. The author assign binary dummy values for four external account restriction categories, being: the presence of multiple exchange rates; restrictions on current account transactions; restrictions on capital account transactions; and requirements of the surrender of export proceeds. Thus, Chinn and Ito (2008) aim to capture the level of capital openness rather than merely measure the capital control intensity. Chinn and Ito (2008)'s index is measured based on five-year windows and is updated until 2012.

A large value of FDI or FOP corresponds with a high degree of financial integration. Since it is hypothesised that the growth-enhancing effect of a competitive real exchange rate is larger in economies that are less financially integrated, the interaction terms of the RER misalignment indices with FDI and FOP are expected to have negative signs. Similarly, the interaction terms of the RER misalignment indices with H are expected to be negative, while the interaction terms of the RER misalignment indices with N are expected to be positive.

7.2.2 Empirical estimate strategy

To avoid spurious correlations in the panel data regression results, it is required that the data exhibits stationarity over the time dimensions. The Im, Pesaran, and Shin (2003)'s panel data unit root test, which has an advantage of being able to deal with unbalanced data, is conducted to examine the time-series property of variables. However, it is noteworthy that the rejection of the null hypothesis in the Im, Pesaran, and Shin (2003)'s test means that there is at least one stationary series in the panel. Thus, the significance of the Im, Pesaran, and Shin (2003)'s test does not imply that all series in the panel are stationary.

Table 7.1 presents the results of the Im, Pesaran, and Shin (2003)'s tests using different criteria to choose the number of lags. Three popular information criteria are considered: Akaike Information Criterion (AIC) (Akaike, 1974); Schwarz' Bayesian Information Criterion (BIC) (Schwarz, 1978); and Hannan-Quinn Information Criterion (HQIC) (Hannan & Quinn, 1979). A variable is justified as stationary when the null hypothesis of unit root is statistically rejected at the 10% level in all tests using alternative information criteria. According to this criterion, the panel unit root test rejects the null hypothesis of stationarity in five out of six RER misalignment indices. $MIS6$ is found to be non-stationary and is not used in the next growth model regression section. Also, the empirical evidence fails to reject the null hypothesis in the panel unit root test in the rest of the variable set.

Table 7.1: Im et al. (2003) panel unit root tests

Information criterions	AIC	BIC	HQIC
	W_{t-bar}		
$MIS1$	-2.8806***	-2.0644**	-3.1115***
$MIS2$	-2.0815**	-1.5729*	-1.8866**
$MIS3$	-1.8826**	-1.4331*	-1.6380*
$MIS4$	-1.2910*	-1.2910*	-1.2910*
$MIS5$	-1.8231**	-1.9841**	-1.9841**
$MIS6$	-0.9509	-0.4795	-0.9509
$GDPG$	-10.7776 ***	-11.1024***	-11.6275***
FDI	-2.6189***	-4.0739***	-2.8897***
GOV	-2.5882***	-3.1372***	-3.4332***
INF	-7.4662***	-6.1296***	-5.4811***
FCF	-2.4049***	-2.6205***	-2.6205***
FPO[a]	-1.5585*		

[a]: *There was an insufficient number of time periods to compute W_{t-bar} as lagged terms are introduced in the Augmented Dickey–Fuller regressions. For this reason, zero lag length was used*.

****, ** and * indicate significance at 1%, 5% and 10%, respectively.*

Source: *The author*

As the sample was characterised by a large time dimension and a small panel dimension, the panel-corrected standard error (PCSE) estimator proposed by Beck and Katz (1995) was applied. The nature of the PCSE method is to compute the panel-corrected standard error under the assumption of contemporaneously correlated disturbance across panels, while making use of parameters estimated by OLS or Prais–Winsten regression (Prais &

Winsten, 1954). The choice between OLS or Prais–Winsten regressions depends on the existence of a serial correlation in the disturbance. The lag length of explanatory variables in Equation (7.1) was determined by the 'general to specific' testing strategy proposed by Hall (1994) and Campbell and Perron (1991). Starting from a chosen maximum lag length of a variable, $P^{max} = 5$, if its highest lag term is not statistically significant, then lag length is reduced by one. This reduction process was iterated until either achieving significance or $p = 1$.

A test for the existence of serial correlation in a panel-data model developed by Wooldridge (2010) was conducted. The null hypothesis of no first-order serial correlation was rejected at the 1% level in all model specifications. Consequently, a first-order serial correlation (AR(1)) structure of disturbances was specified for the panel data models in which a common coefficient of the AR(1) process was applied to all the panels. Prais–Winsten estimates were produced in regressions.

7.2.3 Data

The sources of data used in this chapter are presented in Table 7.2. The RER misalignment indices were estimated in Chapter 5. $GDPG$, FDI, GOV, INF, and FCF were directly sourced from the The World Bank DataBank. This database is updated regularly and is available on the official World Bank website (*http://databank.worldbank.org*). Finally, FPO were computed by the method developed by Chinn and Ito (2008) and updated until 2012. This data is available online at the website: *http://web.pdx.edu/~ito/Chinn-Ito_website.htm*.

The descriptive statistics of the panel data variables used in the TFP determinant regression model are given in Table 7.3. Correlations among variables in the growth regression model are provided in Table 7.4. Notably, the correlation between FDI and FPO is fairly high and this could raise the concern about the collinearity in the model. In order to address the collinearity issues, a variant of model (7.1) in which FDI is dropped form the control variable set is regressed and reported in Appendix A.

Table 7.2: Data sources for the growth regression model

Variables	Definition	Source
$MIS1$, $MIS2$, $MIS3$, $MIS4$, $MIS5$	RER misalignment indices	Estimated in Chapter 5
$GDPG$	The real GDP growth rate	The World Bank DataBank
FDI	The ratio of foreign direct investment inflow to GDP	
GOV	The ratio of government spending to GDP	
INF	The inflation rate	
FCF	The ratio of gross fixed capital formation in GDP	
FPO	Financial openness indicator	Chinn and Ito (2008)

Source: *The author*

Table 7.3: Descriptive statistics of variables in growth models

Variable	*Number of observation*	*Mean*	*Std. Dev.*	*Min*	*Max*
$GDPG$	434	0.0443	0.0437	-0.2636	0.1615
$MIS1$	377	0.9998	0.2024	0.4371	1.7809
$MIS2$	434	1.0022	0.3075	0.2746	2.2641
$MIS3$	242	1.0003	0.1609	0.6141	1.6097
$MIS4$	246	1.0022	0.1687	0.5179	1.7552
$MIS5$	242	0.9999	0.1284	0.5940	1.6636
FDI	310	0.0453	0.0650	-0.0276	0.3865
FOP	355	0.4181	1.4529	-1.8640	2.4390
GOV	443	0.1045	0.0277	0.0511	0.1878
INF	380	0.1164	0.6176	-0.0402	11.3625
FCF	415	0.2662	0.0699	0.0950	0.4682

Note: *Data in the range 1961-2012*

Source: The a*uthor's estimation using data from the World Bank DataBank*

Table 7.4: Correlation between variables in the growth regression model

	$GDPG$	$MIS1$	$MIS2$	$MIS3$	$MIS4$	$MIS5$	FDI	FOP	GOV	INF	FCF
$GDPG$	1										
$MIS1$	-0.0173	1									
$MIS2$	-0.0900	0.6939	1								
$MIS3$	0.0437	0.9616	0.6633	1							
$MIS4$	-0.0289	0.733	0.8492	0.7651	1						
$MIS5$	0.0276	0.7915	0.5895	0.8053	0.5977	1					
FDI	0.0947	0.0074	0.112	0.0445	0.0612	0.0214	1				
FOP	-0.1050	-0.2071	0.135	-0.1425	0.0916	-0.1091	0.4998	1			
GOV	0.1559	-0.2509	-0.2754	-0.2336	-0.28	-0.1825	-0.1595	-0.1647	1		
INF	-0.3102	0.3103	0.3711	0.2193	0.2973	0.2799	-0.2564	-0.1664	-0.2462	1	
FCF	0.4291	0.0621	-0.1236	0.1159	-0.0696	0.1095	-0.0437	-0.0715	0.2458	-0.0731	1

Note: *Data in the range 1980-2012*

Source: The author's calculation using data from the World Bank DataBank

7.3 Empirical analysis

The estimations of the impact of the RER misalignment on economic growth are presented in Tables 7.5-7.9. Each table displays the results of six regressions. The first regression estimates the effect of the RER misalignment and a set of control variables on output growth, without an interaction term. In the rest of the regressions, interaction terms between RER misalignment and measures of financial integration are added. The second regression employed FDI as a proxy for financial integration, whereas the third regression used Chinn and Ito's (2008) capital openess indicator. The last three regressions examined the divergence of the growth effect of RER misalignment among sub-groups of countries classified by their degree of financial integration.

The results of the regression in which the RER mislignment index is estimated by Dollar (1992)'s method are shown in Tables 7.5 and 7.6. Table 7.5 shows the model that uses the $MIS1$ index and Table 7.6 uses the $MIS2$ index. In the regression (1) in Table 7.5, the coefficient of $MIS1$ is 0.0225 and is statistically significant at the 5% level. The magnitude of the effect of the RER misalignment on economic growth is slightly smaller in the model using $MIS2$. In the regression (1) in Table 7.6, the coefficient of $MIS2$ is 0.0199 and is also significant at the 5% level. Therefore, the positive and significant effect of RER undervaluation on output growth is found in both models with alternative RER misalingment indices. The point estimates of the coefficients of $MIS1$ and $MIS2$ imply that undervaluation at the 10% level causes the economic growth rate to rise by 0.225% and 0.199%, respectively. Notably, because the model captures a linear relationship between RER misalignment and growth, the empirical result also means that a higher degree of overvaluation reduces economic growth. These results are consistent with previous studies on the relationship between RER and growth that considered different country samples (e.g. Bereau et al., 2012; Bhalla, 2007; Bleaney & Greenaway, 2001; Blecker & Razmi, 2008; Gala, 2008; Hausmann et al., 2005; Prasad et al., 2007; Razin & Collins, 1999; Rodrik, 2008; Vieira & MacDonald, 2012).

Regression (2) examines the interaction between the RER mislignment and the financial integration degree proxied by the ratio of FDI inflow to GDP. The interaction terms are found to be statistically insignificant in both models using $MIS1$ and $MIS2$, although their signs are negative as expected. By contrast, using Chinn and Ito (2008)'s financial openness indicator to proxy for financial integration, the interaction terms are expectedly negative and statistically significant in both models using $MIS1$ and $MIS2$. The interaction terms between $MIS1$ and FOP are significant at the 5% level, whereas the interaction terms between $MIS2$ and FOP are significant at the 10% level.

Categorial dummies are used to proxy for the financial integration level in the regressions (4), (5), and (6). Dummies for newly industrial countries and transitional countries are examimed separatedly in the regressions (5) and (6), and together in the regression (4). The empircal evidence supports the hypothesis that the growth effect of a depreciated RER is more robust in transitional countries than those in semi-industrial countries. Both interaction terms of $MIS1$ and $MIS2$ with L are positive and statistically significant at the 1% level in regressions (4) and (5). This means that the combined interacted and non-interacted coefficient of the RER misalignment in transitional countries is statistically higher than in other East Asian countries. By contrast, the interaction terms between the RER misalignment indices and N have expected negative signs but are not statistically significant. This implies that there is no substantial difference in the effect of the RER misalignment on economic growth in semi-industrial and newly industrial East Asian countries.

Table 7.5: PCSE regression of the growth model, using $MIS1$ index

	(1)	(2)	(3)	(4)	(5)	(6)
$GDPG_{t-1}$	0.4951*** *(0.0759)*	0.5000*** *(0.0750)*	0.4690*** *(0.0737)*	0.3450*** *(0.0722)*	0.3699*** *(0.0716)*	0.4982*** *(0.0744)*
$MIS1_{t-1}$	0.0225** *(0.0103)*	0.0304** *(0.0120)*	0.0371*** *(0.0120)*	-0.0118 *(0.0152)*	0.0089 *(0.0100)*	0.0277** *(0.0135)*
Financial integration proxies and interaction terms						
FDI_{t-1}	-0.0303 *(0.0305)*	0.1132 *(0.1248)*	-0.0340 *(0.0315)*	-0.0749** *(0.0309)*	-0.0368 *(0.0293)*	-0.0322 *(0.0307)*
$(MIS1 * FDI)_{t-1}$		-0.1497 *(0.1382)*				
FOP_{t-1}			0.0147** *(0.0071)*			
$(MIS1 * FOP)_{t-1}$			-0.0148** *(0.0071)*			
L				-0.1204*** *(0.0452)*	-0.1076*** *(0.0414)*	
$(MIS1 * L)_{t-1}$				0.1369*** *(0.0417)*	0.1182*** *(0.0378)*	
H				-0.0239 *(0.0198)*		0.0116 *(0.0184)*
$(MIS1 * H)_{t-1}$				0.0339 *(0.0212)*		-0.0109 *(0.0198)*
Control variables						

GOV_{t-1}	0.1963*** *(0.0655)*	0.2008*** *(0.0633)*	0.1909*** *(0.0653)*	0.0739 (0.0665)	0.1045* *(0.0598)*	0.1946*** *(0.0657)*
INF_{t-1}	-0.0631* *(0.0343)*	-0.0690** *(0.0343)*	-0.0750** *(0.0332)*	-0.0824** (0.0346)	-0.0981*** *(0.0324)*	-0.0682* *(0.0357)*
INF_{t-2}	0.0461* *(0.0278)*	0.0461* *(0.0275)*	0.0433 *(0.0272)*	0.0223 (0.0248)	0.0218 *(0.0267)*	0.0451 *(0.0278)*
FCF_{t-1}	0.0580 *(0.0370)*	0.0604 *(0.0373)*	0.0719** *(0.0363)*	0.0464 (0.0391)	0.0587* *(0.0354)*	0.0584 *(0.0390)*
$Intercept$	-0.0380*** *(0.0135)*	-0.0463*** *(0.0143)*	-0.0538*** *(0.0147)*	0.0121 (0.0223)	-0.0095 *(0.0145)*	-0.0430*** *(0.0161)*
Time fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Wooldridge test for autocorrelation	F(1,8)=207.649 Prob>F=0.0000	F(1,8)=207.076 Prob>F=0.0000	F(1,8)=207.549 Prob>F=0.0000	F(1,8)=182.335 Prob>F=0.0000	F(1,8)=205.773 Prob>F=0.0000	F(1,8)=204.274 Prob>F=0.0000
AR(1) specification	Yes	Yes	Yes	Yes	Yes	Yes
No. of observation	283	283	283	283	283	283
R-squared	0.6459	0.6496	0.6502	0.6736	0.6705	0.6673

Note: *When AR(1) process of error is specified, the coefficients were estimated by Prais–Winsten regression.*
Standard errors are presented in parentheses.
****, ** and * indicate significance at 1%, 5% and 10%, respectively.*
Dependent variable: growth rate of per capita output.
Source: The author

Table 7.6: PCSE regression of the growth model, using $MIS2$ index

	(1)	(2)	(3)	(4)	(5)	(6)
$GDPG_{t-1}$	0.4847*** *(0.0763)*	0.4890*** *(0.0755)*	0.4544*** *(0.0752)*	0.3409*** *(0.0755)*	0.3552*** *(0.0748)*	0.4876*** *(0.0744)*
$MIS2_{t-1}$	0.0199** *(0.0099)*	0.0282*** *(0.0106)*	0.0328*** *(0.0110)*	-0.0009 *(0.0121)*	0.0095 *(0.0090)*	0.0246* *(0.0129)*
Financial integration proxies and interaction terms						
FDI_{t-1}	-0.0415 *(0.0310)*	0.1113 *(0.0989)*	-0.0337 *(0.0322)*	-0.0756** *(0.0309)*	-0.0389 *(0.0297)*	-0.0430 *(0.0313)*
$(MIS2 * FDI)_{t-1}$		-0.1445 *(0.0948)*				
FOP_{t-1}			0.0107 *(0.0067)*			
$(MIS2 * FOP)_{t-1}$			-0.0118* *(0.0063)*			
L				-0.1053** *(0.0465)*	-0.1060** *(0.0450)*	
$(MIS2 * L)_{t-1}$				0.1244*** *(0.0437)*	0.1188*** *(0.0421)*	
H				-0.0065 *(0.0173)*		0.0102 *(0.0168)*
$(MIS2 * H)_{t-1}$				0.0164 *(0.0183)*		-0.0092 *(0.0180)*
Control variables						

GOV_{t-1}	0.1833*** *(0.0657)*	0.1942*** *(0.0643)*	0.1796*** *(0.0647)*	0.1127* *(0.0615)*	0.1233** *(0.0622)*	0.1860*** *(0.0656)*
INF_{t-1}	-0.0688* *(0.0352)*	-0.0749** *(0.0347)*	-0.0804** *(0.0346)*	-0.0812** *(0.0342)*	-0.0933*** *(0.0334)*	-0.0730** *(0.0357)*
INF_{t-2}	0.0390 *(0.0280)*	0.0385 *(0.0276)*	0.0320 *(0.0274)*	0.0155 *(0.0285)*	0.0231 *(0.0274)*	0.0383 *(0.0279)*
FCF_{t-1}	0.0704* *(0.0363)*	0.0690* *(0.0359)*	0.0761** *(0.0359)*	0.0338 *(0.0371)*	0.0661* *(0.0358)*	0.0692* *(0.0377)*
$Intercept$	-0.0359*** *(0.0131)*	-0.0425*** *(0.0129)*	-0.0458*** *(0.0128)*	0.0062 *(0.0152)*	-0.0119 *(0.0135)*	-0.0399*** *(0.0145)*
Time fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Wooldridge test for autocorrelation	F(1,8) = 223.162 Prob> F =0.0000	F(1,8) =224.797 Prob> F =0.0000	F(1,8) =275.974 Prob> F =0.0000	F(1,8) =185.628 Prob> F =0.0000	F(1,8) =215.752 Prob> F =0.0000	F(1,8) =218.249 Prob> F =0.0000
AR(1) specification	Yes	Yes	Yes	Yes	Yes	Yes
No. of observations	283	283	283	283	283	283
R-squared	0.6439	0.6477	0.6473	0.6707	0.6654	0.6455

Note: *When AR(1) process of error is specified, the coefficients were estimated by Prais–Winsten regression.*
Standard errors are presented in parentheses.
****, ** and * indicate significance at 1%, 5% and 10%, respectively.*
Dependent variable: growth rate of per capita output.
Source: The author

Tables 7.7 and 7.8 present the results of regressions using the RER misalignment indices estimated by Elbadawi et al. (2008)'s method. The influence of RER misalignment on economic growth is illustrated in the regressions (1). The coefficient of $MIS3$ is 0.0209 and significant at the 10% level, while the coefficient of $MIS4$ is 0.0263 and significant at the 5% level. These coefficients of $MIS3$ and $MIS4$ mean that a 10% depreciation in the RER causes the economic growth rate to improve by 0.209% and 0.263%, respectively. These figures are in line with those derived from the regressions using $MIS1$ and $MIS2$.

Unlike the models using the RER misalignment indices estimated by Dollar (1992)'s method, the models using $MIS3$ and $MIS4$ demonstrate negative and statistically significant interaction terms between the RER misalignment indices and FDI. The interaction terms with FDI are found to be significant at the 5% level in the regression using $MIS3$ and the 10% level in the regression with $MIS4$ (regressions (2), (Tables 7.7 and 7.8).

When Chinn and Ito's (2008) capital openess index replaces FDI to proxy for financial integration, the coefficients of interaction terms in both regressions with $MIS3$ and $MIS4$ are negative and significant at the 1% level (regressions (3), (Tables 7.7 and 7.8). This result is consistent with the empirical evidence derived from the regressions with $MIS1$ and $MIS2$.

Similar to the regressions with $MIS1$ and $MIS2$, regressions (4) and (5) in Tables 7.7 and 7.8 show positive and statistically significant interaction terms of $MIS3$ and $MIS4$ with L. All of these interaction terms are found to be significant at the 1% level. The interaction terms between $MIS4$ with H are negative and statistically significant at the 10% level (regression (6) in Table 7.8). However, the interaction terms between $MIS3$ with H are negative but not statistically significant (regression (6) in Table 7.7). In general, the empirical results support the hypothesis that there is a stronger positive impact of a competitive exchange rate on less financially integrated countries.

Table 7.7: PCSE regression of the growth model, using $MIS3$ index

	(1)	(2)	(3)	(4)	(5)	(6)
$GDPG_{t-1}$	0.4762*** (0.0789)	0.4746*** (0.0768)	0.4007*** (0.0756)	0.3466*** (0.0756)	0.3541*** (0.0745)	0.4724*** (0.0764)
$MIS3_{t-1}$	0.0209* (0.0120)	0.0386*** (0.0139)	0.0691*** (0.0153)	-0.0069 (0.0176)	0.0070 (0.0126)	0.0385*** (0.0147)
Financial integration proxies and interaction terms						
FDI_{t-1}	-0.0347 (0.0317)	0.2404* (0.1299)	-0.0441 (0.0316)	-0.0744** (0.0317)	-0.0409 (0.0308)	-0.0339 (0.0302)
$(MIS3 * FDI)_{t-1}$		-0.2832** (0.1427)				
FOP_{t-1}			0.0327*** (0.0089)			
$(MIS3 * FOP)_{t-1}$			-0.0324*** (0.0088)			
L				-0.1152** (0.0483)	-0.1084** (0.0424)	
$(MIS3 * L)_{t-1}$				0.1332*** (0.0462)	0.1212*** (0.0404)	
H				-0.0064 (0.0226)		0.0370* (0.0216)
$(MIS3 * H)_{t-1}$				0.0163 (0.0242)		-0.0365 (0.0232)
Control variables						

GOV_{t-1}	0.1840*** (0.0694)	0.1904*** (0.0668)	0.1518** (0.0701)	0.0739 (0.0665)	0.0939 (0.0657)	0.1735** (0.0687)
INF_{t-1}	-0.0574 (0.0352)	-0.0696** (0.0349)	-0.0987*** (0.0344)	-0.0824** (0.0346)	-0.0940*** (0.0330)	-0.0745** (0.0361)
INF_{t-2}	0.0558** (0.0268)	0.0559** (0.0264)	0.0566** (0.0256)	0.0223 (0.0248)	0.0269 (0.0243)	0.0535** (0.0264)
FCF_{t-1}	0.0758* (0.0399)	0.0806** (0.0401)	0.1205*** (0.0407)	0.0464 (0.0391)	0.0694* (0.0380)	0.0824** (0.0408)
$Intercept$	-0.0395** (0.0156)	-0.0574*** (0.0169)	-0.0896*** (0.0181)	0.0121 (0.0223)	-0.0085 (0.0180)	-0.0565*** (0.0173)
Time fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Wooldridge test for autocorrelation	F(1,8)=121.434 Prob>F=0.0000	F(1,8)=111.006 Prob>F=0.0000	F(1,8)=117.338 Prob>F=0.0000	F(1,8)=127.206 Prob>F=0.0000	F(1,8)=121.195 Prob>F=0.0000	F(1,8)=123.795 Prob>F=0.0000
AR(1) specification	Yes	Yes	Yes	Yes	Yes	Yes
No. of Observations	240	240	240	240	240	240
R-squared	0.6623	0.6698	0.6799	0.6889	0.6845	0.6673

Note: *When AR(1) process of error is specified, the coefficients were estimated by Prais–Winsten regression.*
Standard errors are presented in parentheses.
****, ** and * indicate significance at 1%, 5% and 10%, respectively.*
Dependent variable: growth rate of per capita output.
Source: The author

Table 7.8: PCSE regression of the growth model, using $\mathbf{MIS4}$ index

	(1)	(2)	(3)	(4)	(5)	(6)
$GDPG_{t-1}$	0.4682*** (0.0789)	0.4632*** (0.0778)	0.4145*** (0.0756)	0.3684*** (0.0747)	0.3762*** (0.0744)	0.4401*** (0.0756)
$MIS4_{t-1}$	0.0263** (0.0117)	0.0403*** (0.0127)	0.0534*** (0.0132)	0.0102 (0.0151)	0.0095 (0.0114)	0.0521*** (0.0164)
Financial integration proxies and interaction terms						
FDI_{t-1}	-0.0392 (0.0314)	0.1816 (0.1129)	-0.0391 (0.0327)	-0.0629** (0.0315)	-0.0387 (0.0306)	-0.0281 (0.0305)
$(MIS4 * FDI)_{t-1}$		-0.2160* (0.1121)				
FOP_{t-1}			0.0215*** (0.0081)			
$(MIS4 * FOP)_{t-1}$			-0.0221*** (0.0078)			
L				-0.0989** (0.0415)	-0.1064*** (0.0397)	
$(MIS4 * L)_{t-1}$				0.1151*** (0.0390)	0.1179*** (0.0376)	
H				0.0167 (0.0239)		0.0499** (0.0244)
$(MIS4 * H)_{t-1}$				-0.0086 (0.0253)		-0.0506* (0.0262)
Control variables						
GOV_{t-1}	0.1891*** (0.0703)	0.1904*** (0.0668)	0.1384* (0.0745)	0.0756 (0.0689)	0.0875 (0.0693)	0.1928*** (0.0691)

INF_{t-1}	-0.0660* (0.0353)	-0.0761** (0.0350)	-0.0882*** (0.0341)	-0.0850*** (0.0328)	-0.0854*** (0.0323)	-0.0932*** (0.0357)
INF_{t-2}	0.0534** (0.0268)	0.0535** (0.0266)	0.0479* (0.0253)	0.0288 (0.0249)	0.0331 (0.0247)	0.0499* (0.0260)
FCF_{t-1}	0.0887** (0.0394)	0.0915** (0.0392)	0.1164*** (0.0400)	0.0611 (0.0381)	0.0790** (0.0383)	0.1061*** (0.0399)
$Intercept$	-0.0481*** (0.0166)	-0.0613*** (0.0169)	-0.0700*** (0.0161)	-0.0069 (0.0205)	-0.0117 (0.0184)	-0.0740*** (0.0198)
Time fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Wooldridge test for autocorrelation	F(1,8)=120.255 Prob>F=0.0000	F(1,8)=121.970 Prob>F=0.0000	F(1,8)=124.364 Prob>F=0.0000	F(1,8)=112.927 Prob>F=0.0000	F(1,8)=115.970 Prob>F=0.0000	F(1,8)=115.714 Prob>F=0.0000
AR(1) specification	Yes	Yes	Yes	Yes	Yes	Yes
No. of Observations	240	240	240	240	240	240
R-squared	0.6681	0.6739	0.6762	0.6925	0.6879	0.6736

Note: *A first-order autoregressive process of error was specified and the coefficients were estimated by Prais–Winsten regression.*
Standard errors are presented in parentheses.
****, ** and * indicate significance at 1%, 5% and 10%, respectively.*
Dependent variable: growth rate of per capita output.
Source: The author

Table 7.9 presents the regression using $MIS5$, the RER misalignment index estimated by Razin and Collins (1999)'s method. The effect of $MIS5$ on economic growth is examined in regression (1). Similar to other RER misalignment indices in previous models, $MIS5$ is found to have a positive effect on GDP growth. The coefficient of $MIS5$ is 0.0256 and is statistically significant at the 10% level (regression (1)). This point estimate implies that devaluation at the 10% level improves the economic growth rate by 0.256%.

In regression (2), the interaction terms between $MIS5$ and FDI have negative sign as expected but are not statistically significant. The interaction terms between $MIS5$ and FOP are examined in regression (3), and is found to be negative and statistically significant at the 1% level. According to the categorical proxies, the interaction terms between $MIS5$ and L are positive and significant at the 10% level in regression (5) and at the 5% level in regression (4). The interaction terms between $MIS5$ and H are negative but not statistically significant in both regressions (4) and (6). In summary, the positive effect of undervaluation on economic growth is found with all RER misalignment indices. The magnitude of this effect changes only slightly when different RER misalignment indices are used. In general, devaluation at the 10% level causes the economic growth rate to rise in the range of 0.199 - 0.263%.

There is overall evidence that a competitive exchange rate plays a greater role in promoting economic growth in countries that have a low degree of financial integration. By using FDI as a proxy for the degree of financial integration, all of the interaction terms between the RER misalignment and financial integration have negative signs as expected, although interaction terms of $MIS3$ and $MIS4$ are the only ones that are statistically significant. The empirical evidence is more robust when FOP is used to proxy for the degree of financial integration. All of the interaction terms between the RER misalignment indices and FOP are negative and are statistically significant. There is consistent evidence that the growth enhancing effect of a competitive RER is stronger in East Asian transitional countries than that in other regional countries. Nevertheless, there is only modest evidence that a competitive RER affects East Asian newly industrialised countries differently to their regional semi-industrialised counterparts.

Table 7.9: PCSE regression of the growth model, using $\mathbf{MIS5}$ index

	(1)	(2)	(3)	(4)	(5)	(6)
$GDPG_{t-1}$	0.4739*** *(0.0791)*	0.4737*** *(0.0788)*	0.3956*** *(0.0810)*	0.3396*** *(0.0772)*	0.3509*** *(0.0754)*	0.4750*** *(0.0788)*
$MIS5_{t-1}$	0.0256* *(0.0139)*	0.0288** *(0.0134)*	0.0564*** *(0.0144)*	-0.0035 *(0.0177)*	0.0208 *(0.0143)*	0.0129 *(0.0136)*
Financial integration proxies and interaction terms						
FDI_{t-1}	-0.0348 *(0.0315)*	0.0612 *(0.2163)*	-0.0272 *(0.0316)*	-0.0693** *(0.0312)*	-0.0414 *(0.0309)*	-0.0386 *(0.0307)*
$(MIS5 * FDI)_{t-1}$		-0.0958 *(0.2232)*				
FOP_{t-1}			0.0328*** *(0.0113)*			
$(MIS5 * FOP)_{t-1}$			-0.0334*** *(0.0113)*			
L				-0.0724 *(0.0484)*	-0.0581 *(0.0421)*	
$(MIS5 * L)_{t-1}$				0.0961** *(0.0462)*	0.0781* *(0.0403)*	
H				-0.0438 *(0.0340)*		-0.0330 *(0.0296)*
$(MIS5 * H)_{t-1}$				0.0522 *(0.0340)*		0.0344 *(0.0298)*
Control variables						
GOV_{t-1}	0.1718** *(0.0683)*	0.1749*** *(0.0656)*	0.1742*** *(0.0676)*	0.1059* *(0.0593)*	0.1232** *(0.0603)*	0.1699** *(0.0682)*

INF_{t-1}	-0.0629* *(0.0355)*	-0.0639* *(0.0355)*	-0.0840** *(0.0344)*	-0.0863** *(0.0349)*	-0.1048*** *(0.0334)*	-0.0519 *(0.0357)*
INF_{t-2}	0.0562** *(0.0268)*	0.0570** *(0.0269)*	0.0635** *(0.0269)*	0.0236 *(0.0251)*	0.0265 *(0.0241)*	0.0574** *(0.0267)*
FCF_{t-1}	0.0769* *(0.0404)*	0.0781* *(0.0413)*	0.1195*** *(0.0429)*	0.0465 *(0.0411)*	0.0588 *(0.0404)*	0.0754* *(0.0409)*
$Intercept$	-0.0430*** *(0.0167)*	-0.0467*** *(0.0160)*	-0.0807*** *(0.0180)*	0.0047 *(0.0188)*	-0.0226 *(0.0171)*	-0.0310** *(0.0159)*
Time fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Wooldridge test for autocorrelation	F(1,8)=122.786 Prob>F=0.0000	F(1,8)=124.308 Prob>F=0.0000	F(1,8)=121.039 Prob>F=0.0000	F(1,8)=118.201 Prob>F=0.0000	F(1,8)=121.836 Prob>F=0.0000	F(1,8)=117.787 Prob>F=0.0000
AR(1) specification	Yes	Yes	Yes	Yes	Yes	Yes
No. of Observations	240	240	240	240	240	240
R-squared	0.6610	0.6617	0.6736	0.6874	0.6810	0.6628

Note: A first-order autoregressive process of error was specified and the coefficients were estimated by Prais–Winsten regression.
Standard errors are presented in parentheses.
****, ** and * indicate significance at 1%, 5% and 10%, respectively.*
Dependent variable: growth rate of per capita output.
Source: The author

Notably, FDI is used as a control variable in the Equation (7.1) as it reflects the degree of openness of an economy. However, this could raise worries about the collinearity between FDI and other financial integration indicators. Appendix A presents the results of regressions in which FDI is not used as a control variable. Dropping FDI from the control variable bundle causes slight changes in the regression results but does not refute the significance of the interaction terms between the RER misalignment and financial integration. For example, the sign and significant levels of the interaction terms between the RER misalignment and financial integration in the regressions using MIS3, MIS4 and MIS5 (Tables 3A, 4A and 5A) are much similar between models with and without FDI used as a control variable. The absence of FDI has more impact on the regressions using MIS1 and MIS2 (Tables 1A and 2A). While the significance of the interaction terms between the RER misalignment and the categorical proxies of financial integration (L and H) is preserved, the interaction terms between the RER misalignment and FPO remain to be negative but turn out to be insignificant.

7.4 Conclusion

Following the success of some developing countries in manipulating domestic currencies to support economic growth, there is a huge body of empirical literature that provides evidence for the growth enhancing effect of undervaluation. In this study, it is argued that instead of examining separately the impact of the RER misalignment, it is important to consider the interaction between the RER misalignment and financial integration, especially in economies relying on export-led growth strategies like those of East Asian countries. The hypothesis is that a competitive exchange rate could play a greater role in promoting economic growth in countries that have a low degree of financial integration.

This study focuses on a relatively small number of diversified economies that share similarities, rather than the large sample commonly used in other studies. The panel data for East Asian countries largely validate the hypothesis. This result is practically important as it suggests that a competitive exchange rate is not a general solution for economic growth in every country. It seems that the effectiveness of a competitive exchange rate policy depends greatly on the circumstances in which it is applied and the degree of financial integration is an essential factor.

An important policy implication of the interaction between the RER misalignment and financial integration is that the benefit of a policy targeting an undervalued RER could be substantial when it helps a less financially integrated economy overcome the obstacles caused by a balance of payments constraint. In contrast, in a highly financially integrated economy not facing a serious balance of payments constraint, such a policy has minor benefit that might not outweigh its negative side effects.

CHAPTER 8

THE REAL EXCHANGE RATE MISALIGNMENT AND PRODUCTIVITY IN EAST ASIAN ECONOMIES

8.1 Introduction

Literature has so far documented a large amount of empirical evidence on the effect of a depreciated RER on economic growth. However, there has been surprisingly little attention given to the transmission channels through which a depreciated RER influences economic growth. One of the dominant theoretical views highlights the role of a depreciated RER in improving an economy's aggregate productivity. For example, Rodrik (2008) pointed out the role of a depreciated RER in obtaining an economy's optimal structure and hence supporting the productivity channel in the following ways. Firstly, the optimal structure implies a higher level of an economy's productivity. Secondly, a depreciated RER enlarges the tradables sector, which is able to generate productivity improvement through the "learning by doing" process (Matsuyama, 1992). Similar argument can be found in McLeod and Mileva (2011) who argued that a depreciated RER reallocates labour from the non-tradables sector to the tradables sector and thereby accelerates the "learning by doing" process. More recently, assuming that the skill level is a positive function of past employment, Tervala (2013) studied a depreciated RER in a dynamic general equilibrium system and pointed out that it can increase the skill level of an economy through the learning by doing process.

This chapter empirically examines the effect of the RER misalignment on the total factor productivity (TFP) in East Asian countries. The RER misalignment is measured by the indices estimated in Chapter 5, while TFP is estimated by two alternative frameworks: the primal growth accounting method; and the nonparametric frontier analysis method. Because there is no consensus on a reliable method to measure TFP, using alternative estimation approaches could reduce the severity of measurement errors and improve the robustness of empirical evidences. In order to investigate the correlation between the RER misalignment and productivity, this chapter, in essence, specifies TFP determinant models in which the RER misalignment is an explanatory variable.

The empirical analysis in this chapter is closest to that used in recent papers by Mbaye (2012) and McLeod and Mileva (2011), which both relied on the growth accounting framework developed by Bosworth and Collins (2003) to estimate TFP. While McLeod and Mileva (2011) used the REER, which would not necessarily be a correct measure of the RER misalignment unless the PPP hypothesis holds, Mbaye (2012) estimated the RER misalignment by the reduced equation approach. This study is fundamentally different from Mbaye (2012) and McLeod and Mileva (2011) in the following ways. Firstly, it is a more comprehensive study that employs alternative approaches to estimate TFP and the RER misalignment. Notably, theoretical understanding does not provide a precise instruction on algorithms to measure the RER misalignment and TFP. Moreover, empirical results could be severely affected by the methods used to estimate the RER misalignment and TFP. This highlights that a comprehensive analysis is important to avoid misleading empirical results caused by measurement errors. Secondly, this study focuses on a relatively small and homogenous sample of East Asian countries whereas Mbaye (2012) and McLeod and Mileva (2011) investigated larger and more heterogeneous samples, consisting of both developing and developed countries.

The remainder of this chapter is organised as follows. Section 8.2 describes TFP estimation frameworks and discusses the consistency of estimation results derived from alternative approaches. Section 8.3 presents model specifications and the estimation strategy, and provides descriptive details and sources of data. Section 8.4 carries out empirical regressions and discuses empirical results. Finally, section 8.5 summarises findings from the chapter and suggests further research.

8.2 TFP estimation frameworks

The concept of TFP is essentially attached to the Solow-Swan neoclassical growth model (R. M. Solow, 1956; Swan, 1956) in which output is a function of production inputs such as capital, labour and land, and an exogenous variable representing the aggregate productivity. TFP is, therefore, equated to the portion of output expansion not being accounted for by the increase in inputs. Thus, TFP is estimated by using data on the output and inputs rather than being directly observed.

The literature proposes two popular approaches to measure TFP: the growth accounting method; and the frontier analysis method. The growth accounting method is primal as it is straightforwardly derived from residuals of a Solow production function. Therefore, it is deemed to be a simple and consistent framework. On the other hand, it is largely subjected to the estimated values of factor income shares, which are often not directly observed but instead determined by ad hoc methods without reliable statistical evidence. The frontier analysis approach is essentially based on the idea that the efficiency of an economy could be measured by its distance to the production frontier. In this regard, the improvement in TFP could be allocated to the increase in the efficiency level and the movement of the production frontier. Based on the estimation technique, the frontier analysis approach could be further divided into parametric (e.g. stochastic frontier analysis) and non-parametric types (e.g. data envelopment analysis). While the data envelopment analysis (DEA) method has been widely applied to estimate TFP in panel data studies, the application of the stochastic frontier analysis method is mostly restricted to cross-section data models[19]. Moreover, the DEA method has an advantage over the growth accounting and stochastic frontier analysis methods in that it does not require the assumption of a specific production function. In this study,

[19] There are some studies advancing the application of stochastic frontier analysis in panel data models, for example, Battese and Coelli (1995); Cornwell, Schmidt, and Sickles (1990); Kumbhakar (1990); Kumbhakar, Ghosh, and McGuckin (1991); Pitt and Lee (1981). Nevertheless, some strong assumptions on the movement pattern have to be made in order to estimate the efficiency term.

TFP is measured by both the primal growth accounting method and the DEA method.

8.2.1 The growth accounting framework

In general, the growth accounting method decomposes the growth of output into the contributions of input factor accumulations and TFP. It assumes perfect competition to ensure that the factor income shares equal the factor elasticities.

Following R. Solow (1957), a production function consists of two inputs: capital stock (K) and number of workers (labour) (L), and is supposed constant returns to scale.

$$Y_t = A_t F(K_t, L_t) \tag{8.1}$$

where Y is output; K is capital stock; L is labour; A is the term of efficiency; and t is the time indicator. For the sake of brevity, the time subscript is dropped for the rest of this section.

Differentiating both side of Equation (8.1) with respect to t:

$$\dot{Y} = \dot{A}F(K,L) + A\frac{\partial F}{\partial K}\dot{K} + A\frac{\partial F}{\partial L}\dot{L} \tag{8.2}$$

$$\Rightarrow \quad \frac{\dot{Y}}{Y} = \frac{\dot{A}}{A} + \frac{\partial F}{\partial K}\frac{\dot{K}}{F(K,L)} + \frac{\partial F}{\partial L}\frac{\dot{L}}{F(K,L)} \tag{8.3}$$

$$\Rightarrow \quad \frac{\dot{Y}}{Y} = \frac{\dot{A}}{A} + \left(\frac{\partial F}{\partial K}\frac{Y}{F(K,L)}\right)\frac{K}{Y}\frac{\dot{K}}{K} + \left(\frac{\partial F}{\partial L}\frac{Y}{F(K,L)}\right)\frac{L}{Y}\frac{\dot{L}}{L} \tag{8.4}$$

$$\Rightarrow \quad \frac{\dot{Y}}{Y} = \frac{\dot{A}}{A} + \left(\frac{\partial F}{\partial K}\frac{Y}{F(K,L)}\right)\frac{K}{Y}\frac{\dot{K}}{K} + \left(\frac{\partial F}{\partial L}\frac{Y}{F(K,L)}\right)\frac{L}{Y}\frac{\dot{L}}{L} \tag{8.5}$$

$$\Rightarrow \quad y = a + \left(r\frac{K}{Y}\right)k + \left(w\frac{L}{Y}\right)l \tag{8.6}$$

$$\Rightarrow \quad TFP = a = y - S_K k - S_L l \tag{8.7}$$

where a dot over a variable indicates a time derivative and a lower case indicates the growth rate of a variable. r and w are respectively service prices of capital and labour. S_K and S_L are respectively income shares of capital and labour, $S_K + S_L = 1$.

On the right hand side of Equation (8.7), the output growth rate (y) and the labour growth rate (l) are the only variables for which statistical data are available. In order to measure the capital stock growth rate (k), this study estimates capital stock based on statistical data on investment, the level of initial capital stock and the rate of capital depreciation. Moreover, there is no statistical data on the income shares of capital and hence a rational level needs to be assumed.

First, the perpetual inventory method is employed to estimate the sampled countries' capital stock. The idea of the perpetual inventory method is that the capital stock is the outcome of an investment stream. This can be described by the formula:

$$\Rightarrow \qquad K_t = (1-\varphi)^t K_0 + \sum_{i=0}^{t-1} I_{t-1}\,(1-\varphi)^i \tag{8.8}$$

where K_0 is initial capital stock; I is investment volume; and φ is the capital depreciation rate, which is assumed to be 5% in this chapter[20].

This study makes use of Harberger (1988)'s ad hoc method to estimate initial capital stock. This method equates the capital growth rate corresponding with initial capital stock to the growth rate of output. Consequently, the initial capital stock can be estimated by using data on the growth rate of output, investment volume and the assumed rate of capital depreciation:

$$k_0 = \frac{I_0}{K_0} - \varphi \tag{8.9}$$

$$\Rightarrow \qquad K_0 = \frac{I_0}{k_0 + \varphi} \tag{8.10}$$

[20] See Delpachitra and Dai (2012) for a recent survey of the capital depreciation rate in growth accounting studies

$$\Rightarrow \qquad K_0 \approx \frac{I_0}{y_0 + \varphi} \tag{8.11}$$

Following Harberger (1988), a three-year average growth rate of output and the corresponding three-year average investment volume are used to estimate the capital stock of the base-year, which is the middle year of the three-year period. The capital stock of the base-year is used as the initial capital stock.

An important step in the growth accounting approach is to determine the parameters of factor income shares that are not provided by statistical offices in most of developing countries. There is indeed no consensus on the level of factor income share. For example, the United Nations National Accounts Statistics data, 1992 edition, shows enormous variation in countries' income shares. The lowest labour income share is 0.051 in Ghana, while the largest figure is 0.770 in Ukraine[21].

Following Bosworth and Collins (2003), this study set a constant labour income share at 0.65 for all sampled countries.

8.2.2 The DEA framework

The application of the frontier analysis in estimating the TFP is based on the concept of the Malmquist TFP index. The Malmquist index was first introduced by pioneering studies of Caves, Christensen, and Diewert (1982a, 1982b) who developed the idea proposed by Malmquist (1953) in using a ratio of a distance function as a quantity index. In general, the Malmquist TFP index could be input-orientated or output-orientated depending on how the distance is calculated. The two orientations derive identical results if production is constant returns to scale; otherwise, they result in different numerical measures.

Following, Fare, Grosskopf, Norris, and Zhang (1994), productivity growth is measured as a geometric mean of two Malmquist TFP indices which can be decomposed into two components: changes in efficiency; and technology

[21] See Delpachitra and Dai (2012) for a recent survey of the factor income share in the growth accounting studies

improvement. The Malmquist TFP index measures the productivity change between two periods t_1 and t_2. Let (x_1, y_1) and (x_2, y_2) be respectively the set of inputs and output at periods t_1 and t_2. Under a common technology, the Malmquist TFP index is the ratio between the distances of two data points, t_1 and t_2. If the technology at t_1 is used as the reference technology, the Malmquist TFP output oriented index between t_1 and t_2 is measured as:

$$M^1 = \frac{D^1(x_2, y_2)}{D^1(x_1, y_1)} \tag{8.12}$$

In the case that the technology at t_2 is used as the reference technology, the Malmquist TFP index between t_1 and t_2 is defined alternatively:

$$M^2 = \frac{D^2(x_2, y_2)}{D^2(x_1, y_1)} \tag{8.13}$$

where D^1 and D^2 are distance functions corresponding with the reference technology. Value of M greater than 1 indicates a productivity improvement, and inverse. Fare et al. (1994) argued that M^1 and M^2 are equivalent only if the technology is Hicks neutral[22]. To avoid the arbitrariness in selecting one of two reference technologies, Fare et al. (1994) made use of a geometric mean of M^1 and M^2.

$$M = \left(\frac{D^1(x_2, y_2)}{D^1(x_1, y_1)} \frac{D^2(x_2, y_2)}{D^2(x_1, y_1)}\right)^{1/2} \tag{8.14}$$

Furthermore, the geometric mean index can be decomposed in to the efficiency change and the technology change. Rearrange Equation (8.14):

$$M = \frac{D^2(x_2, y_2)}{D^1(x_1, y_1)} \left(\frac{D^1(x_2, y_2)}{D^2(x_2, y_2)} \frac{D^1(x_1, y_1)}{D^2(x_1, y_1)}\right)^{1/2} \tag{8.15}$$

in which

[22] This concept refers to a class of production function in which the balance of outputs or inputs does not depend on technical changes. It was first introduced by Hicks (1963).

$$\text{Efficiency change} = \frac{D^2(x_2, y_2)}{D^1(x_1, y_1)} \tag{8.16}$$

$$\text{Techinical change} = \left(\frac{D^1(x_2, y_2)}{D^2(x_2, y_2)} \frac{D^1(x_1, y_1)}{D^2(x_1, y_1)}\right)^{1/2} \tag{8.17}$$

In order to obtain the Malmquist TFP index, the production frontier must be estimated, followed by calculation of the distance functions $D^1(\boldsymbol{x_1}, \boldsymbol{y_1})$, $D^1(x_2, y_2)$, $D^2(\boldsymbol{x_1}, \boldsymbol{y_1})$ and $D^2(x_2, y_2)$. This study applies the well-known DEA method developed by Fare et al. (1994). Supposing that there are K countries, each country uses N inputs $x_n^{k,t}$ to produce M outputs $y_m^{k,t}$ over T periods. Using the technology at time t as reference, the distance function for a point A corresponding with inputs x_n^A and outputs y_m^A is defined by a linear program as below:

$$[D^t(x_n^A, y_m^A)]^{-1} = \max \theta \tag{8.18}$$

subject to:

$$\theta y_m^A \leq \sum_{k=1}^{K} z^{k,t} y_m^{k,t} \quad \forall m \in [1, M] \tag{8.19}$$

$$x_n^A \geq \sum_{k=1}^{K} z^{k,t} x_n^{k,t} \quad \forall n \in [1, N] \tag{8.20}$$

$$z^{k,t} \geq 0 \tag{8.21}$$

$$\sum_{k=1}^{K} z^{k,t} = 1 \tag{8.22}$$

where θ is a scalar; and $z^{k,t}$ includes k constant. The condition (8.22) is used because a constant returns to scale production function is assumed in this studies. The GDP is the single output variable in the model whereas labour force and capital stock are two input variables.

8.2.3 TFP estimation results

It is worth noting that unlike the growth accounting method, the DEA method can avoid the measurement errors associated with factor income shares, which are unlikely to be accurately estimated. Nevertheless, both of methods are exposed to measurement errors in estimating capital stock. The estimate results from the two methods are presented in Table 8.1. According to both methods, Vietnam is the country attaining the lowest TFP growth rate in the period 1991-2012. While the TFP growth rate estimated by the growth accounting method is highest in China, Singapore is the best performing country according to the estimation result from the DEA method.

Table 8.1: TFP estimation results

Country	Growth accounting (%) (TFP_GA)		DEA method (TFP_DEA)		Data range	TFP_GA and TFP_DEA correlation
	Mean	*Std. error*	*Mean*	*Std. error*		
Indonesia	*1.7050*	*4.0586*	*0.9994*	*0.0393*	*1991-2012*	*0.9016*
Malaysia	*1.7751*	*3.4333*	*0.9936*	*0.0335*	*1991-2012*	*0.8035*
Philippines	*1.2561*	*2.7145*	*1.0093*	*0.0220*	*1991-2012*	*0.9501*
Thailand	*2.1296*	*4.1474*	*0.9984*	*0.0402*	*1991-2012*	*0.7740*
Hong Kong	*1.4837*	*3.6380*	*1.0056*	*0.0346*	*1991-2012*	*0.9928*
South Korea	*1.6244*	*2.5740*	*0.9815*	*0.0253*	*1991-2012*	*0.9299*
Singapore	*2.4041*	*4.3748*	*1.0272*	*0.0436*	*1991-2012*	*0.9890*
China	*5.5024*	*2.2019*	*1.0003*	*0.0190*	*1991-2012*	*0.8202*
Vietnam	*1.0806*	*1.1477*	*0.9624*	*0.0175*	*1991-2012*	*0.8123*

Source: *The author*

In general, the estimation results are fairly consistent between the two methods. The TFP growth rates estimated by the growth accounting method (TFP_GA) and the DEA method (TFP_DEA) appear to be highly correlated. The estimation results are almost identical between the two methods in the case of Hong Kong as they demonstrate the correlation ratio of 0.9928, which is the highest among the sampled countries. The estimation results of the two methods are most divergent in the case of Thailand where their correlation ratio is 0.7740. Considering the panel as a whole, the overall correlation ratio of the TFP growth rates estimated by the two methods is 0.7733.

8.3 Methodology and data

8.3.1 Model specification

The effect of the RER misalignment on TFP is investigated through an empirical TFP determinants model, which includes the RER misalignment as an explanatory variable:

$$TFP\_GA_{it} = \beta_0 + \sum_{p=1}^{m} \beta_{1,p} TFP\_GA_{i,t-p} + \sum_{p=1}^{n} \beta_{2,p} MIS_{i,t-p} + \sum_{p=1}^{l} \gamma CV_{i,t-p} + u_{it} \qquad (8.23)$$

$$TFP\_DEA_{it} = \beta_0 + \sum_{p=1}^{m} \beta_{1,p} TFP\_DEA_{i,t-p} + \sum_{p=1}^{n} \beta_{2,p} MIS_{i,t-p} + \sum_{p=1}^{l} \gamma CV_{i,t-p} + u_{it} \qquad (8.24)$$

where i and t are the cross-section and time indicators; TFP_GA and TFP_DEA are respectively the TFP growth rate measured by the growth accounting and DEA methods; and MIS is the RER misalignment. The contemporary terms of explanatory variables are dropped to avoid the endogeneity problem. CV is a vector of control variables, including the ratio of government final consumption expenditure to GDP (GOV); the ratio of foreign direct investment inflows to GDP (FDI); the ratio of agricultural value-added to GDP (AGR); the ratio of credit provided by domestic bank to GDP (DCB); the ratio of domestic credit to private sector to GDP (DCP); the openness measured as the ratio of trade volume (imports and exports) to GDP (OPN); human capital measured by Bosworth and Collins (2003)' method (HUM); and the inflation rate (INF). The selection of control variables can be justified by their theoretical linkages with TFP.

The ratio of government final consumption expenditure to GDP (GOV) represents the relative scale of the public service sector in an economy. It could influence TFP in various ways, both positive and negative. On the one hand, public service provided by government, such as compulsory education and public healthcare systems, research and development activities and public administration, is essential for economic development. On the other hand, government spending could decrease the level of domestic savings and increase taxes, which could cause distortions in the economy.

The positive effect of FDI on the aggregate productivity seems to be more obvious. Specifically, FDI introduces modern technologies to domestic production through the spill-over effect. It also promotes the immigration of high skilled workers to the host country. Thanks to the diffusion of knowledge, the quality of the domestic labour force could be improved. Moreover, FDI makes the industry more competitive and thereby indirectly increases the efficiency of domestic firms.

The structure of an economy could be an important factor in determining the growth rate of TFP. The fact is that the sources of innovation such as "learning by doing" and foreign technology absorption are mostly found in the industrial sectors. Thus, productivity in the non-agricultural sectors tends to rise faster than in the agricultural sector. For that reason, a country structured with a lower share of the agricultural sector in GDP could obtain a higher rate of TFP growth.

DCB and DCP are two variables proxying for an economy's financial development, which is well documented as an important factor determining the productivity growth, especially in developing countries (e.g. P Aghion, Howitt, & Mayer, 2005; Greenwood & Jovanovic, 1990; Levine, 1997). The primary role of financial development is to improve the efficiency of resource allocation. For example, the more financial development, the more likely it is that capital and labour will be directed to high efficiency sectors. Also, financial development could help a country take full advantage of costly technology transfers.

The openness is an important factor affecting progress of an economy's productivity. Firstly, international trade is a major carrier of knowledge and supports the "learning by doing" processes in domestic firms. For instance, a domestic firm can learn from their foreign partners and take advantage of the knowledge diffusion. International trade is also a primary source to introduce advanced technologies into the domestic market. Secondly, international competition facilitates continuous innovation in domestic firms and directs an economy to its competitive advantages. Moreover, productivity improvement could come from the economies-of-scale effect as domestic firms can access foreign markets.

The negative effect of inflation on productivity has been long examined in the literature, i.e. see Tsionas (2003) for a review. Inflation is believed to create wrong price signals that could result in ineffective resource allocation. In addition, inflation increases macroeconomic instability, which leads to a suboptimal state of the economy; for example, firms increase their spending on unproductive inventories. Such distortions ultimately reduce productivity growth.

Among other factors, human capital (HUM) is intuitively considered as one of the most important determinants of TFP growth. The fact is that a labour force with a higher level of education is more productive, and is also more able to absorb advanced technologies. In this study, the Bosworth and Collins (2003)'s method is applied to measure human capital in the sampled countries.

For details: $HUM = \ln(\sum W_j P_j)$, where P_j is the percentage of population aged over 15 years who achieved a certain educational attainment (P, $j = 1$: no schooling; $j = 1.5$:in-completed primary school; $j = 2$: completed primary school; $j = 2.5$: in-completed secondary school; $j = 3$: completed secondary school; $j = 3.5$: tertiary education; and $j = 4$: completed tertiary education); and W_j is weight of return to level of schooling. Following Bosworth and Collins

(2003), this study assumes a return rate of 7% per schooling year and then W_j becomes: W_1 =100%, $W_{1.5}$ =123%, W_2 =150%, $W_{2.5}$ =184%, W_3 =225%, $W_{3.5}$=258%, and W_4=295%. Because the data on educational attainment are only observed every 5 years over the period from 1970 to 2010, the exponential interpolation is applied to generate missing data for the years between two observations. The data for years 2011 and 2012 are derived by exponentially extrapolating from two data points for the years 2005 and 2010.

8.3.2 Estimation strategy

To avoid spurious correlations in panel data regressions, it must be ensured that data are stationary over the time dimensions. The Im et al. (2003)'s panel data unit root test is conducted to examine the time-series property of variables. The Im, Pesaran, and Shin (2003)'s test has an advantage of being able to deal with unbalanced data. Notably, the rejection of the null hypothesis of panel data unit root tests, including Im, Pesaran, and Shin (2003)'s test, merely implies that there is at least one stationary series in the panel. The significance of the Im, Pesaran, and Shin (2003)'s test does not imply that all series in the panel are stationary.

Table 8.2 presents the results of the Im, Pesaran, and Shin (2003)'s tests in which different criteria are used to choose the lagged terms of variables. Three popular information criteria are considered: Akaike Information Criterion (AIC) (Akaike, 1974); Schwarz' Bayesian Information Criterion (BIC) (Schwarz, 1978); and Hannan-Quinn Information Criterion (HQIC) (Hannan & Quinn, 1979). Given the limitation of panel data unit root tests as mentioned above, a variable is justified as stationary when the null hypotheses of the Im, Pesaran, and Shin (2003)'s test using alternative information criteria are statistically rejected at the 10% level.

The result reveals that all control variables are stationary at level terms or the first difference terms. The HUM variable demonstrates a rather strange property. On the one hand, the unit root tests for level terms of HUM reject the null hypothesis at the 1% level when the BIC and HQIC information criteria are used, but do not reject the null hypothesis when the AIC information criterion is used. On the other hand, although the unit root tests for the first difference terms of HUM reject the null hypotheses at the 10% level, the significance levels of the tests for first difference terms are much lower than for the tests using the BIC and HQIC information criteria for the level terms. It should be noted that if series are stationary at level terms, they are stationary at difference terms. Therefore, the significance of unit root tests for first difference terms is often higher than which for level terms. This abnormal property of HUM is perhaps because it is partly derived by the exponential interpolation and extrapolation techniques.

The tests strongly reject the null hypothesis of unit root in cases of the dependent variables, TFP_GA and TFP_DEA. The tests are significant at the 1% level regardless of which information criterion is used. The evidence of stationarity is also found in cases of the RER misalignment indices except for $MIS6$. In order to make the regression models comparable and consistent, the $MIS6$ index is dropped from the variables set rather than making use of its first difference terms.

The unit root tests indicate that FDI and AGR are stationary at level terms whereas GOV, DCB, DCP and OPN are stationary at first level terms. The first difference terms of GOV , DCB, DCP and OPN are used in the regression models (8.23) and (8.24) because the unit root tests for the level terms fail to reject the null hypothesis of non-stationarity.

The Beck and Katz (1995)'s panel-corrected standard error (PCSE) estimator is used to estimate the regression models (8.23) and (8.24). Because the PCSE coefficient estimator is biased in a panel model with serial correlation, the Wooldridge (2010)'s panel data serial correlation test is first conducted. If the null hypothesis of the Wooldridge (2010)'s test is rejected, the Prais and Winsten (1954)'s method is used to derive estimated coefficients. Moreover, the "general to specific" testing strategy proposed by Hall (1994) and Campbell and Perron (1991) is used to determine the lag length of variables. A maximum lag length for the 'general to specific' testing process is set to be 5. Details of the "general to specific" procedure is presented in Chapter 7.

Table 8.2: Panel data unit root tests for variables in the TFP model

Variables	**AIC**	**BIC**	**HQIC**
		W_{t-bar}	
TFP_GA	-7.1952 ***	-7.9712***	-7.1952 ***
TFP_DEA	-6.2895***	-7.0260***	-6.2895***
GOV	-0.1045	-1.2591*	-1.2591*
ΔGOV	-10.8919***	-11.8468***	-10.8919***
FDI	-3.0639***	-3.7549***	-3.0639**
INF	-8.2943***	-8.2943***	-8.2943***
AGR	-3.3721***	-3.5459***	-3.3721***
DCB	-0.3680	-0.0490	-0.0490
ΔDCB	-9.1738***	-10.1111***	-10.1111***
DCP	-0.1254	-0.0597	-0.0597
ΔDCP	-8.0250***	-9.0423***	-9.0423***
OPN	2.3996	2.3283	2.2298
ΔOPN	-12.0240***	-13.0009***	-12.3365***
HUM	1.7200	-4.0748***	-4.2239***
ΔHUM	-1.3317*	-1.5826*	-1.5826*
$MIS1$	-2.8806***	-2.0644**	-3.1115***
$MIS2$	-2.0815**	-1.5729*	-1.8866**
$MIS3$	-1.8826**	-1.4331*	-1.6380*
$MIS4$	-1.2910*	-1.2910*	-1.2910*
$MIS5$	-1.8231**	-1.9841**	-1.9841**
$MIS6$	-0.9509	-0.4795	-0.9509

Note: ****, ** and * indicate significance at 1%, 5% and 10%, respectively.*

Source: *The author*

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8.3.3 Data

The data used in this study were sourced from the The World Bank DataBank. This database is updated regularly and is available on the official World Bank website (http://databank.worldbank.org). The descriptive statistics of the panel data variables used in the TFP determinant regression model and their correlations are given in Tables 8.3 and 8.4.

Table 8.3: Descriptive statistics of variables in the TFP model

Variable	No. of Obs	Mean	Std. Dev.	Min	Max
TFP_DEA	198	0.9975	0.0356	0.8450	1.0990
TFP_GA	198	2.1068	3.4701	-15.1474	10.9126
$MIS1$	275	1.0000	0.1641	0.5413	1.7809
$MIS2$	291	0.9996	0.2477	0.3450	2.1593
$MIS3$	242	1.0003	0.1609	0.6141	1.6097
$MIS4$	246	1.0022	0.1687	0.5179	1.7552
$MIS5$	242	0.9999	0.1284	0.5940	1.6636
FDI	271	0.0483	0.0684	-0.0276	0.3865
ΔGOV	279	0.0001	0.0077	-0.0425	0.0449
ΔAGR	272	0.1386	0.0955	0.0003	0.4630
ΔDCB	264	0.0244	0.1046	-0.6354	0.6059
ΔDCP	264	0.0212	0.0834	-0.3265	0.3477
ΔOPN	269	0.0338	0.0935	-0.3964	0.4004
ΔHUM	288	0.0107	0.0071	-0.0046	0.0374
INF	272	0.0571	0.0648	-0.0402	0.5839

Note: *Data in the range 1980-2012*

Source*: The author's calculation using data from the World Bank DataBank*

Table 8.4: Correlation between variables in the TFP model

	$MIS1$	$MIS2$	$MIS3$	$MIS4$	$MIS5$	FDI	GOV	AGR	ΔDCB	ΔDCP	ΔOPN	ΔHUM	INF
TFP_DEA	0.0402	0.0261	0.1355	0.0957	-0.051	0.3027	-0.2143	-0.2833	-0.3301	-0.2428	0.3497	0.1318	-0.3537
TFP_GA	-0.0407	-0.0688	0.027	-0.0442	-0.0648	0.1648	-0.319	-0.0643	-0.1983	-0.0397	0.357	0.1643	-0.3112
$MIS2$	0.7426	1											
$MIS3$	0.9692	0.7131	1										
$MIS4$	0.7751	0.8883	0.7886	1									
$MIS5$	0.7566	0.6536	0.7774	0.6366	1								
FDI	-0.1495	0.1183	-0.0996	0.0486	-0.081	1							
ΔGOV	-0.1121	-0.1253	-0.1071	-0.0707	-0.1224	-0.136	1						
AGR	0.4199	0.2455	0.2643	0.2343	0.2573	-0.5442	-0.0198	1					
ΔDCB	-0.1541	-0.0843	-0.1714	-0.1213	-0.0926	0.0733	0.1806	0.0016	1				
ΔDCP	-0.2036	-0.1467	-0.203	-0.1479	-0.1168	0.0916	0.0928	-0.0125	0.8614	1			
ΔOPN	-0.0465	-0.0451	-0.0171	-0.0243	-0.0261	0.2134	-0.261	-0.1308	-0.2022	-0.0373	1		
ΔHUM	0.2227	0.0955	0.2036	0.171	0.1433	-0.0655	0.1029	0.264	-0.0233	0.0952	0.0365	1	
INF	0.5620	0.4940	0.4777	0.4463	0.5708	-0.2225	-0.2866	0.4405	-0.0895	-0.1448	-0.0564	0.0407	1

Note: *Data in the range 1980-2012*

Source: *The author's calculation using data from the World Bank DataBank*

8.4 Empirical result

8.4.1 The baseline panel evidence

In the baseline models, the TFP growth rate is regressed on the lagged terms of itself and the RER misalignment. There are twenty regressions, which investigate different combinations of two alternative measures of the TFP growth rate, five alternative indices of the RER misalignment, and the effects of time dummies. Table 8.5 presents the results for models using the TFP estimated by the growth accounting method and Table 8.6 presents the results with the TFP estimated by the DEA method.

As shown in Table 8.5, the “general to specific” procedure indicates that three RER misalignment indices, $MIS1$, $MIS2$ and $MIS3$, have a lag length of one period. Two other RER misalignment indices, $MIS4$ and $MIS5$, have a lag length of two periods. Because the Wooldridge (2010)’s panel data serial correlation test rejects the null hypothesis of no serial correlation in all of the model specifications, the first-order serial correlation (AR(1)) structure of disturbances was specified and then the Prais–Winsten estimator was applied to derive the estimated coefficients. The primary interest is in the coefficients of the RER misalignment indices and their statistical significance.

Four out of the five RER misalignment indices are found to have positive effect on TFP_GA. The exception is $MIS2$. The coefficients of $MIS2$ are positive but not statistically significant in both the regression with time dummies (regression (2b)) and without time dummies (regression (2a)).

The coefficients of $MIS1$ on TFP_GA are positive and statistically significant at the 5% level in regressions (1a) and (1b). The effect of $MIS1$ on TFP_GA appears to be sizable. The coefficients of $MIS1$ in regressions (1a) and (1b) are 3.2332 and 2.9362, respectively. This means that there is 10% depreciation in the RER, e.g. the $MIS1$ index increases from 1 to 1.1, and leads to an increase of roughly 0.3 percentage points in the TFP growth rate in the next period (TFP_GA is measured in terms of percentage).

The effect of $MIS3$ on TFP_GA is positive and highly significant at the 1% level regardless of whether time dummies are included or excluded. The coefficients of $MIS3$ in the regressions (3a) and (3b) are 3.0841 and 2.8907 respectively, which are slightly lower than the coefficients of $MIS1$ in the regressions (1a) and (1b).

Unlike the two previous cases of $MIS1$ and $MIS3$, the second lag term of $MIS4$ has positive and significant effect on TFP_GA while the first lag term has insignificant effect. This implies that it takes two years for an innovation in the RER misalignment to affect TFP growth. The coefficients of the second lag term of $MIS4$ in the regressions with and without time dummies are significant at the 5% and 10% levels respectively. Notably, adding time dummies into regression (4b) substantially reduces the magnitude of the coefficient of the second lag term of $MIS4$. The coefficient of the second lag term of $MIS4$ is 5.3836 in the regression without time dummies (regression (4a)) whereas it is 3.4458 in the regression with time dummies (regression (4b)).

Similarly, the coefficient of the second lagged term of $MIS5$ is also found to be significant and the coefficient of its first lag term is insignificant. Adding time dummies into regression (5b) also reduces both the magnitude and the significance of coefficient of $MIS5$. The coefficient of the second lag term of $MIS5$ is significant at the 5% level in the regression without time dummies (regression (5a)) and at the 10% level in the regression with time dummies (regression (5b)). In the regression with time dummies, the coefficient of the second lag term of $MIS5$ is larger than the coefficient of $MIS4$. However, in the regression without time dummies, the coefficient of the second lag term of $MIS5$ is smaller than that of 4 . The coefficients of the second lag term of $MIS5$ in the regressions without and with time dummies are 5.2074 and 4.0004 respectively.

Table 8.5: PCSE regression of TFP_GA on RER misalignments

TFP_GA_t	Regressions					
	(1a)	**(1b)**	**(2a)**	**(2b)**	**(3a)**	**(3b)**
TFP_GA_{t-1}	0.1924 (*0.1499*)	0.4464*** (*0.0877)*	0.1934 (*0.1385*)	0.4691*** (*0.0867*)	0.1932* (*0.1078*)	0.4760*** (*0.0729*)
$MIS1_{t-1}$	3.2332** (*1.4774*)	2.9363** (*1.3257*)				
$MIS2_{t-1}$			0.2533 (*0.9148*)	0.2786 (*0.8008*)		
$MIS3_{t-1}$					3.0841*** (1.1575)	2.8907*** (*1.0311*)
$Cons$	-1.5303 (*1.8017*)	-1.9513 (*1.3203*)	1.2284 (*1.2586*)	0.6570 (0.*8398*)	-1.2468 (1.3520)	-1.9600* (*1.0482*)
Time fixed effect	No	Yes	No	Yes	No	Yes
Wooldridge test	F(1,8)=90.761 Prob>F=0.0000	F(1,8)=37.029 Prob>F=0.0003	F(1,8)=109.400 Prob>F=0.0000	F(1,8)=51.237 Prob>F=0.0001	F(1,8)=74.170 Prob>F=0.0000	F(1,8)=44.711 Prob>F=0.0002
AR(1) specification	Yes	Yes	Yes	Yes	Yes	Yes
No. of Obs.	185	185	189	189	172	172
R-squared	0.0547	0.5950	0.0378	0.5797	0.0508	0.6085
Ward test	$\chi^2(2)$ = 7.89 Prob>χ^2=0.0194	$\chi^2(2)$ =5.26e11 Prob>χ^2=0.0000	$\chi^2(2)$ = 2.03 Prob>χ^2=0.3626	$\chi^2(2)$ = 32.89 Prob>χ^2=0.0000	$\chi^2(2)$ = 8.61 Prob>χ^2=0.0135	$\chi^2(2)$ = 1.84e09 Prob>χ^2=0.0000

Table 8.5: PCSE regression of $\mathrm{TFP\_GA}$ on RER misalignments (cont)

TFP_GA_t	Regressions			
	(4a)	**(4b)**	**(5a)**	**(5b)**
TFP_GA_{t-1}	0.1794* (*0.1036*)	0.4539*** (0.0736)	0.1962* (*0.1049*)	0.4680*** (*0.0747*)
$MIS4_{t-1}$	-3.0362 (*2.4177*)	-1.3225 (*2.1036*)		
$MIS4_{t-2}$	5.3836** (*2.3119*)	3.4458* (*2.0092*)		
$MIS5_{t-1}$			-2.0969 (*2.4378*)	-0.8673 (*2.1239*)
$MIS5_{t-2}$			5.2074** (2.3590)	4.004* (2.1181)
$Cons$	-0.4789 (*1.3831*)	-1.1740 (1.0630)	-1.2934 (*1.7112*)	-2.2121* (1.3371)
Time fixed effect	No	Yes	No	Yes
Wooldridge test	F(1,8)=78.227 Prob>F=0.0000	F(1,8)=36.714 Prob>F=0.0003	F(1,8)=81.990 Prob>F=0.0000	F(1,8)=48.613 Prob>F=0.0001
AR(1) specification	Yes	Yes	Yes	Yes
No. of Obs.	170	170	170	170
R-squared	0.0630	0.6067	0.0588	0.6084
Ward test for model specification	$\chi^2(2)$ = 15.69 Prob>χ^2=0.0013	$\chi^2(2)$=3.88e+09 Prob>χ^2=0.0000	$\chi^2(2)$ = 14.33 Prob>χ^2=0.0025	$\chi^2(2)$ = 2.96e+09 Prob>χ^2=0.0000

Note: ****, ** and * indicate significance at 1%, 5% and 10%, respectively.*
Source: *The author*

Table 8.6 presents the results of regressions where TFP estimated by the DEA method is used as a dependent variable. Based on the "general to specific" procedure, all of the RER misalignment indices are determined to have a lag length of one period. Similar to the TFP_GA regressions, the regressions using TFP_DEA exhibit serial correlation. The Wooldridge (2010)'s panel data serial correlation test was conducted and the null hypothesis of no serial correlation was rejected in all specifications of the TFP_DEA determinant model. Again, it was assumed that there was first-order serial correlation and then the Prais–Winsten estimator was used to derive the regression model coefficients.

Four RER misalignment indices, $MIS1, MIS3, MIS4$ and $MIS5$, are found to have positive effect on TFP_DEA. The effect of $MIS2$ on TFP_DEA is not statistically significant. Notably, this result is similar to that found in the TFP_GA determinant regression models.

The effect of $MIS1$ on TFP_DEA is statistically significant at the 1% level in the model without time dummies (regression (1a)) and at the 5% in the model with time dummies (regression (1a)). The coefficients of the first lag term of $MIS1$ in regressions (1a) and (1b) are 0.0348 and 0.0281 respectively. These point estimates imply that 10% depreciation in the RER leads to an increase of roughly 0.3 percentage points in the TFP growth rate after a one year period. Notably, the effect of $MIS1$ on TFP_DEA has similar magnitude to its effect on TFP_GA.

In regressions (3a) and (3b), the effects of $MIS3$ on TFP_DEA are statistically significant at the 1% level. The coefficients of the first lag term of $\mathrm{MIS3}$ in regressions (3a) and (3b) are 0.0462 and 0.0345 respectively. The effects of $MIS3$ on TFP_DEA have slightly larger magnitude than those of $MIS1$. Notably, this is in contrast to the TFP_GA determinant models where the effects of $MIS3$ on TFP_GA have smaller magnitude than those of $MIS1$.

In the TFP_DEA determinant model, the first lag terms of $MIS4$ and $MIS5$ are positive and statistically significant. This is different from the TFP_GA determinant model where the second lag terms of $MIS4$ and $MIS5$ are statistically significant but the first lag terms are not. The effects of $MIS4$ on

TFP_DEA are significant at the 5% level in both regressions, with and without time dummies. The coefficient of the first lag term of $MIS4$ is 0.0262 in regression (4a) whereas it is 0.0218 in regression (4b). These coefficients are substantially smaller than those of $MIS1$ and $MIS3$.

The $MIS5$ variable is found to be statistically significant at the 5% level in the regression without time dummies (regression (5a)). Adding time dummies increases the significance of the $MIS5$ to the 1% level (regression (5a)). The estimated coefficients of the first lag term of $MIS5$ have comparable magnitude to those of $MIS4$. The coefficients of the first lag term of $MIS5$ in the regressions without and with time dummies are 0.0259 and 0.0283 respectively.

In summary, there is consistent empirical evidence for the effect of the RER misalignment on the TFP growth rate. Different TFP estimation approaches do not substantially affect the regression results. Four out of the five examined RER misalignment indices were found to have positive and significant effects on TFP growth rate in both the TFP_GA and TFP_DEA determinant models. In general, the effect of the RER misalignment on TFP growth is sizable. Among a set of regression models, which make use of different combinations of TFP growth rate measurements and the RER misalignment indices, there is small variation in the magnitude of the effect of the RER misalignment on TFP growth. The point estimates of the RER misalignment coefficients show that a 10 percent depreciation in the RER causes the TFP growth rate to rise in a range of 2.18-5.38 percentage points.

Table 8.6: PCSE regression of TFP_DEA on RER misalignments

TFP_DEA_t	Regressions					
	(1a)	**(1b)**	**(2a)**	**(2b)**	**(3a)**	**(3b)**
TFP_DEA_{t-1}	0.3665*** (*0.1332*)	0.6462*** (*0.0826)*	0.3406*** (*0.1270*)	0.6626*** (*0.0809*)	0.3345*** (*0.1037*)	0.6297*** (*0.0789*)
$MIS1_{t-1}$	0.0348*** (*0.0135*)	0.0281** (0.*1258*)				
$MIS2_{t-1}$			-0.0004 (*0.0097*)	-0.0006 (*0.0078*)		
$MIS3_{t-1}$					0.0462*** (0.0107)	0.0345*** (*0.0101*)
$Cons$	0.5978*** (*0.1289*)	0.3241*** (*0.0787*)	0.6584*** (*0.1268*)	0.3365*** (0.*0803*)	0.6195*** (0.0994)	0.3341 *** (*0.0755)*
Time fixed effect	No	Yes	No	Yes	No	Yes
Wooldridge test	F(1,8)=69.160 Prob>F=0.0000	F(1,8)=42.642 Prob>F=0.0002	F(1,8)=72.694 Prob>F=0.0000	F(1,8)=58.170 Prob>F=0.0001	F(1,8)=60.432 Prob>F=0.0000	F(1,8)=53.856 Prob>F=0.0001
AR(1) specification	Yes	Yes	Yes	Yes	Yes	Yes
No. of Obs	185	185	189	189	172	172
R-squared	0.1622	0.7731	0.2136	0.7437	0.1569	0.7796
Ward test	$\chi^2(2)$ = 20.56 Prob>χ^2=0.0000	$\chi^2(2)$ =2.96e09 Prob>χ^2=0.0000	$\chi^2(2)$ = 7.20 Prob>χ^2=0.0273	$\chi^2(2)$ = 67.52 Prob>χ^2=0.0000	$\chi^2(2)$ = 44.04 Prob>χ^2=0.0000	$\chi^2(2)$ = 1.27e09 Prob>χ^2=0.0000

Table 8.6: PCSE regression of TFP_DEA on RER misalignments (cont)

TFP_DEA_t	Regressions			
	(4a)	**(4b)**	**(5a)**	**(5b)**
TFP_DEA_{t-1}	0.3366*** (*0.1045*)	0.6416*** (0.0783)	0.3537*** (*0.1028*)	0.6614*** (*0.0734*)
$MIS4_{t-1}$	0.0262** (0.*0114*)	0.0218** (*0.0098*)		
$MIS5_{t-1}$			0.0259** (*0.0114*)	0.0283*** (*0.0101*)
$Cons$	0.6374*** (*0.1012*)	0.3346 (0.0753)	0.6206*** (*0.1047*)	0.3085*** (0.0719)
Time fixed effect	No	Yes	No	Yes
Wooldridge test	F(1,8)=77.904 Prob>F=0.0000	F(1,8)=63.926 Prob>F=0.0000	F(1,8)=71.040 Prob>F=0.0000	F(1,8)=59.974 Prob>F=0.0001
AR(1) specification	Yes	Yes	Yes	Yes
No. of Obs.	172	172	172	172
R-squared	0.1468	0.7727	0.1388	0.7617
Ward test	$\chi^2(2)$ = 20.20 Prob>χ^2=0.0000	$\chi^2(2)$=1.58e09 Prob>χ^2=0.0000	$\chi^2(2)$ = 14.42 Prob>χ^2=0.0007	$\chi^2(2)$ = 7.12e08 Prob>χ^2=0.0000

Note: ****, ** and * indicate significance at 1%, 5% and 10%, respectively.*

Source: *The author*

8.4.2 Robustness: control variables

The baseline regression models are fairly sparse as they only take into account a small set of dependent variables including the RER misalignment, the lagged terms of dependent variables, and the time fixed effect. The time fixed effect can replace determinants of TFP growth that are cross-country invariant. However, determinants that are cross-country variant are still left out. This could make the estimate of the RER misalignment coefficient biased if the neglected cross-country variant determinants of TFP growth are correlated to the RER misalignment.

In this section, additional covariates are augmented into the baseline regression models. Following the "general to specific" procedure, the TFP growth rate is regressed on the lagged terms of itself and a set of control variables to identify the lag length of the control variables. Notably, the RER misalignment is excluded in this step and there is a single lag structure of control variables used in regressions with different RER misalignment indices. The empirical results indicate that the lag structures of control variables are identical in models using TFP_GA and TFP_DEA. The lag length is found to be three periods in the case of FDI; two periods in the case of ΔOPN; and one period in the remaining control variables including ΔGOV, AGR, ΔDCB, ΔDCP, HUM and INF. Only the first lag term of TFP growth rate is statistically significant as an explanatory variable of itself.

After the lag structure of control variables had been identified, the RER misalignment variable is added into the regression models and the "general to specific" procedure is applied to identify the lag length of RER misalignment indices. It is found that all of five RER misalignment indices have a lag length of one period.

Similar to the baseline models, models with additional covariates have the serial correlation problem. The Wooldridge (2010)'s panel data serial correlation test rejected the null hypothesis of no serial correlation and hence the Prais–Winsten estimator is used to estimate the coefficients in regression models .

Table 8.7 presents the regression results of the models using the TFP growth rate measured by the growth accounting. Similar to the baseline regression models, the effect of $MIS2$ on TFP_GA is not statistically significant in the models with additional covariates. The evidence of a positive effect of the RER misalignment on TFP_GA is found in regression using the other RER misalignment indices.

Adding control variables retains the positive effect of $MIS1$ on TFP_GA, significant at the 5% level in the regression without time dummies (regression (1a)) whereas it increases the significance of this effect to the 1% level in the regression with time dummies (regression (1b)). The coefficients of $MIS1$ in regressions (1a) and (1b) are 3.6527 and 4.8927 respectively. Notably, the coefficients of $MIS1$ in the model with additional covariates are slightly higher than the estimated coefficients of $MIS1$ in the baseline models where they are 0.1924 and 0.4464 in the regressions without and with time fixed effect, respectively.

The effect of $MIS3$ on TFP_GA remains highly statistically significant in the regressions with additional covariates. The significance levels are 5% in the regression without time dummies (regression (3a)) and 1% in the regression with time dummies (regression (3b)). Similar to the case of $MIS1$, the coefficients of $MIS3$ in the models using control variables are slightly higher than those in the baseline models. The coefficients of $MIS3$ are 3.1894 and 4.3345 respectively in the regressions without and with time dummies whereas they are 3.0841 and 2.8907 respectively in the baseline models.

Whereas the existence of control variables increases both in magnitude and significance of the coefficients of $MIS1$ and $MIS3$ in the TFP_GA determinant model, it weakens the statistical correlation between $MIS4$ and TFP_GA. While $MIS4$ is highly statistically significant at the 1% level in both baseline regression models with and without time dummies, it turns out to be not statistically significant in the regression without time dummies and significant at only the 10% level in the regression with time dummies when the control variables are included. The coefficients of $MIS4$ are 0.8819 and 1.9492 respectively in the regressions with and without time dummies. Those point estimates imply that the effect of $MIS4$ on TFP_GA in the models with additional covariates is substantially smaller than which in the baseline models. Moreover, the control variables also affect the lagged structure of $MIS4$ as the first lag term of $MIS4$ instead of its second lag term is found to have significant effect on the dependent variable.

Similar to the case of $MIS4$, the coefficient of $MIS5$ is not statistically significant in the regression without time dummies (regression (5a)). This is in contrast to the baseline model in which the effect of $MIS5$ on TFP_GA is positive and statistically significant at the 1% level. The significance level of $MIS5$ in the regression with time dummies (regression (5b)) is 5% whereas it is 1% in the baseline model. The coefficients of $MIS5$ are at similar levels with those of $MIS4$ and both of them are substantially lower than those in the baseline models. The coefficients of $MIS5$ in the regressions with and without time dummies are 1.0722 and 3.2329 respectively.

Regarding the correlation between the control variables and TFP_GA, there is concrete evidence for the positive effect of HUM on TFP_GA. The coefficients of HUM are positive in all regressions and statistically significant in the majority of them. INF is found to have negative and statistically significant effect on TFP_GA in three regressions: (1b), (3b) and (5b). Also, the coefficient of INF is negative in nine out of ten regressions. Notably, the effects on TFP_GA of HUM and INF are theoretically expected.

There is consistent empirical evidence supporting the positive effect of government spending on TFP_GA. All regressions demonstrate positive and statistically significant coefficients of GOV. Despite that the size of the agricultural sector is strongly expected to negatively influence productivity growth, the empirical evidence for this relationship is only found regression (1a). FDI and OPN have inconsistent effects on TFP_GA. While the third lag term of FDI has a positive influence on TFP_GA, its second lag term has a negative effect. Similarly, the second and first lag terms of OPN appear to cancel each other out. Finally, the hypothesis on the role of financial development in promoting TFP growth is not supported by the empirical evidence. Two proxies for financial development, DCP and DCB, are statistically insignificant in all regressions. Moreover, the coefficients of these proxies in the majority of regressions are negative rather than positive as expected.

The results of regressions using TFP growth rate measured by the DEA method are showed in the Table 8.8. With the exception of $MIS2$, all of the RER misalignment indices are found to have positive and significant effects on TFP_DEA. This result is consistent with those in the baseline models and the extended models using TFP_GA.

Using additional covariates leads to higher point estimates of the $MIS1$ coefficients. The coefficients of $MIS1$ are estimated to be 0.0593 and 0.0553 in the regressions without and with time dummies, respectively. They are almost two times as high as those in the baseline models. The significance levels of $MIS1$ are at the 1% level in both regression models without and with time dummies.

The effect of $\mathrm{MIS3}$ on $\mathrm{TFP\_DEA}$ remains highly statistically significant at the 1% level in regressions with additional covariates. The estimated coefficients of $MIS3$ in the extended models are close to those in the baseline regression models. They are 0.0488 and 0.0450 respectively in regressions (3a) and (3b).

Adding control variables decreases the significance of the coefficients of $MIS4$ and $MIS5$ in the TFP_DEA determinant model. While $MIS4$ is statistically significant at the 5% level in both baseline models with and without time dummies, it turns out to be significant at the 10% level in the model using additional covariates. Nevertheless, the coefficients of $MIS4$ are 0.0240 and 0.0227 respectively in regressions (4a) and (4b), which are roughly equal to those in the baseline regressions.

Table 8.7: PCSE regression of $\mathrm{TFP\_GA}$ on RER misalignments and additional covariates

TFP_GA_t	Regression				
	(1a)	**(1b)**	**(2a)**	**(2b)**	**(3a)**
TFP_GA_{t-1}	0.3174*** *(0.0856)*	0.4915*** *(0.0722)*	0.3424*** (*0.0870)*	0.5311*** *(0.0705)*	0.3184*** *(0.0863)*
$MIS1_{t-1}$	3.6527** *(1.5256)*	4.8927*** *(1.4057)*			
$MIS2_{t-1}$			0.1517 (*1.1868)*	1.0667 *(1.0200)*	
$MIS3_{t-1}$					3.1894** *(1.5825)*
FDI_{t-1}	1.7710 *(5.9236)*	-1.4127 *(4.8675)*	1.6913 (*5.7431)*	-2.3534 *(4.5536)*	2.5476 *(6.0076)*
FDI_{t-2}	-27.2300*** *(6.7645)*	-20.6076*** *(6.0239)*	-27.6692*** (*6.5681)*	-21.0495*** *(5.6472)*	-27.1028*** *(6.8197)*
FDI_{t-3}	22.3958*** *(6.2786)*	21.2617*** *(5.0604)*	23.8608*** (*6.1562)*	22.5147*** *(4.7824)*	23.4095*** *(6.3730)*
ΔGOV_{t-1}	79.5841*** *29.3713)*	71.8522*** *(25.1834)*	76.8493** (*30.2273)*	66.1361** *(25.9144)*	78.5991*** *(29.9786)*
AGR_{t-1}	-4.6773** *(2.3189)*	-0.5600 *(2.3063)*	-3.2104 (*2.2965)*	0.5382 *(2.1064)*	-1.1366 *(2.5039)*
ΔDCB_{t-1}	-0.5279 *(3.8264)*	2.4924 *(3.0785)*	-0.0094 (*3.8039)*	3.0186 *(2.9456)*	-0.5696 *(3.8283)*
ΔDCP_{t-1}	-2.6627 *(4.6032)*	-3.3043 *(3.6539)*	-3.9612 (*4.5723)*	-4.8355 *(3.5524)*	-3.0722 *(4.6035)*

ΔOPN_{t-1}	-6.0968** *(2.6455)*	-2.6027 *(2.3347)*	-6.3874** *(2.7935)*	-2.4236 *(2.2372)*	-6.0503** *(2.6677)*
ΔOPN_{t-2}	6.2442** *(2.7693)*	3.9712* *(2.3203)*	6.0804** *(2.7935)*	3.8504* *(2.2323)*	6.1843** *(2.7959)*
HUM_{t-1}	75.9337** *(33.6078)*	24.6925 *(24.4377)*	94.8066*** *(33.3716)*	50.9872** *(25.6124)*	72.1512** *(33.5636)*
INF_{t-1}	-3.6420 *(3.8675)*	-8.9560** *(3.7856)*	0.4878 *(4.0541)*	-4.0472 *(3.5158)*	-3.6607 *(3.8273)*
$Cons$	-2.1218 *(1.3714)*	-3.2373*** *(1.2310)*	0.7676 *(1.0615)*	-0.0253 *(0.9430)*	-2.0269 *(1.5234)*
Time fixed effect	No	Yes	No	Yes	No
Wooldridge test for autocorrelation	F(1,8)=93.078 Prob>F=0.0000	F(1,8)=101.980 Prob>F=0.0000	F(1,8)=95.126 Prob>F=0.0000	F(1,8)=93.417 Prob>F=0.0000	F(1,8)=90.427 Prob>F=0.0000
AR(1) specification	Yes	Yes	Yes	Yes	Yes
No. of Obs	175	175	175	175	171
R-squared	0.2485	0.6823	0.2412	0.6679	0.2457
Ward test for model specification	$\chi^2(2)$ = 92.65 Prob>χ^2=0.0000	$\chi^2(2)$ =7.72 e+09 Prob>χ^2=0.0000	$\chi^2(2)$ = 96.51 Prob>χ^2=0.0000	$\chi^2(2)$ = 9.37e+06 Prob>χ^2=0.0000	$\chi^2(2)$ = 85.78 Prob>χ^2=0.0000

Table 8.7: PCSE regression of $\mathrm{TFP\_GA}$ on RER misalignments and additional covariates (cont)

TFP_GA_t	Regression				
	(3b)	**(4a)**	**(4b)**	**(5a)**	**(5b)**
TFP_GA_{t-1}	0.5291*** *(0.0729)*	0.3455*** *(0.0865)*	0.5587*** *(0.0699)*	0.3498*** *(0.0870)*	0.5713*** *(0.0711)*
$MIS3_{t-1}$	4.3345*** *(1.4002)*				
$MIS4_{t-1}$		0.8819 *(1.2896)*	1.9492* *(1.1470)*		
$MIS5_{t-1}$				1.0722 *(1.6791)*	3.2329** *(1.3389)*
FDI_{t-1}	-1.7433 *(4.8134)*	2.1002 *(5.8795)*	-2.5330 *(4.5293)*	2.0066 *(5.8722)*	-2.4789 *(4.5661)*
FDI_{t-2}	-20.7782*** *(5.9546)*	-27.6054*** *(6.6893)*	-21.4070*** *(5.5971)*	-27.1598*** *(6.6728)*	-20.4625*** *(5.7092)*
FDI_{t-3}	22.9223*** *(5.0250)*	24.2115*** *(6.2606)*	22.9991*** *(4.8173)*	24.5013*** *(6.2886)*	23.4781*** *(4.7756)*
ΔGOV_{t-1}	65.6380*** *(25.0756)*	76.2988** *(30.2388)*	58.6983** *(25.4970)*	77.4549** *(30.5849)*	64.2591** *(25.5322)*
AGR_{t-1}	2.3997 *(2.2857)*	-1.4071 *(2.5296)*	1.4997 *(2.3309)*	-0.9527 *(2.5338)*	2.6583 *(2.3100)*
ΔDCB_{t-1}	3.2088 *(3.0999)*	-0.1451 *(3.7562)*	3.6903 *(2.9578)*	-0.1819 *(3.7755)*	3.7662 *(3.0090)*
ΔDCP_{t-1}	-4.0655 *(3.7355)*	-3.9686 *(4.5305)*	-5.0113 *(3.6207)*	-4.0842 *(4.4903)*	-5.5768 *(3.6089)*
ΔOPN_{t-1}	-1.8932 *(2.3055)*	-6.2393** *(2.6582)*	-1.6601 *(2.2166)*	-6.2455** *(2.6885)*	-1.6743 *(2.2273)*

ΔOPN_{t-2}	3.6038 *(2.2948)*	6.1450** *(2.8023)*	3.6910* *(2.2029)*	6.0718** *(2.8074)*	3.3378 *(2.2174)*
HUM_{t-1}	23.3100 *(22.7810)*	85.1590** *(33.3592)*	42.8297* *(23.5738)*	84.1515** *(32.9658)*	34.6819 *(23.9115)*
INF_{t-1}	-8.3864** *(3.6786)*	-1.1825 *(3.7909)*	-5.4507 *(3.4843)*	-1.4093 *(4.2066)*	-7.3592** *(3.4917)*
$Cons$	-3.0585** *(1.3094)*	0.0093 *(1.2331)*	-0.8778 *(1.0729)*	-0.2450 *(1.6580)*	-2.1663* *(1.3106)*
Time fixed effect	No	No	Yes	No	Yes
Wooldridge test for autocorrelation	$F(1,8)$=111.709 Prob>F=0.0000	$F(1,8)$=89.481 Prob>F=0.0000	$F(1,8)$=102.750 Prob>F=0.0000	$F(1,8)$=91.499 Prob>F=0.0000	$F(1,8)$=94.180 Prob>F=0.0000
AR(1) specification	Yes	Yes	Yes	Yes	Yes
No. of Obs	171	171	171	171	171
R-squared	0.7067	0.2428	0.6971	0.2441	0.7038
Ward test for model specification	$\chi^2(2)$ = 8.58+08 Prob>χ^2=0.0000	$\chi^2(2)$ =89.20 Prob>χ^2=0.0000	$\chi^2(2)$ = 7.78e+08 Prob>χ^2=0.0000	$\chi^2(2)$ = 88.17 Prob>χ^2=0.0000	$\chi^2(2)$ = 4.68e+08 Prob>χ^2=0.0000

*Note: ***, ** and * indicate significance at 1%, 5% and 10%, respectively.*

Source: The author

The effect of $MIS5$ on TFP_DEA is not statistically significant in the regression without time dummies (regression (5a)), which is similar to the case for the regression using TFP_GA. This is in contrast to the result of the baseline model in which the effect of $MIS5$ on TFP_DEA is significant at the 5% level. The significance level of $MIS5$ in the regression with time dummies (regression (5b)) is 5% which is lower than the level of 1% in the baseline model. The coefficient of $MIS5$ in regression (5b) is 0.0288, which is roughly equal to the coefficient of $MIS5$ in the baseline model.

The impact of control variables on TFP growth changes slightly from the TFP_DEA model to the TFP_GA model. The coefficients of HUM remain positive in all regressions and are statistically significant in all regressions except regressions (1b), (3b) and (5b). GOV is found to have positive and statistically significant effect on TFP_DEA in all regressions, which is similar to the TFP_GA model. However, the effect of INF is not statistically significant in the TFP_DEA determinant model, whereas it is negative and statistically significant in all of the TFP_GA regressions.

The negative effect of AGR on TFP_DEA is statistically significant in all regressions. This is theoretically expected. Moreover, while finance development is theoretically expected to positively influence TFP growth, DCP is surprisingly found to have negative and significant effect on TFP_DEA. Finally, similar to the TFP_GA determinant models, there is no evidence for significant effects of FDI, OPN and DCB in the TFP_DEA determinant models.

Table 8.8: PCSE regression of $\mathrm{TFP\_DEA}$ on RER misalignments and additional covariates

$\boldsymbol{TFP\_DEA_t}$	Regression				
	(1a)	**(1b)**	**(2a)**	**(2b)**	**(3a)**
TFP_DEA_{t-1}	0.3308*** *(0.0770)*	0.5595*** *(0.0622)*	0.3946*** *(0.0781)*	0.6400*** *(0.0610)*	0.3336*** *(0.0786)*
$MIS1_{t-1}$	0.0593*** *(0.0149*	0.0553*** *(0.0143)*			
$MIS2_{t-1}$			0.0105 *(0.0113)*	0.0096 *(0.0103)*	
$MIS3_{t-1}$					0.0488*** *(0.0154*
FDI_{t-1}	0.0077 *(0.0578)*	-0.0280 *(0.0488)*	-0.0035 *(0.0558)*	-0.0431 *(0.0464)*	0.0189 *(0.0590)*
FDI_{t-2}	-0.2283*** *(0.0656)*	-0.1727*** *(0.0595)*	-0.2339*** *(0.0640)*	-0.1761*** *(0.0568)*	-0.2287*** *(0.0662)*
FDI_{t-3}	0.2073*** *(0.0613)*	0.2035*** *(0.0513)*	0.2279*** *(0.0593)*	0.2221*** *(0.0484)*	0.2183*** *(0.0622)*
ΔGOV_{t-1}	1.0534*** *(0.2762)*	0.9020*** *(0.2485)*	1.0322*** *(0.2835)*	0.8221*** *(0.2494)*	1.0592*** *(0.2805)*
AGR_{t-1}	-0.1531*** *(0.0266)*	-0.0839*** *(0.0250)*	-0.1279*** *(0.0260)*	-0.0594** *(0.0233)*	-0.1101*** *(0.0270)*
ΔDCB_{t-1}	0.0188 *(0.0356)*	0.0349 *(0.0296)*	0.0251 *(0.0363)*	0.0406 *(0.0293)*	0.0201 *(0.0356)*
ΔDCP_{t-1}	-0.0829* *(0.0447)*	-0.0650* *(0.0361)*	-0.0941** *(0.0445)*	-0.0758** *(0.0348)*	-0.0907** *(0.0446)*

ΔOPN_{t-1}	-0.0558** *(0.0253)*	-0.0233 *(0.0225)*	-0.0609** *(0.0257)*	-0.0223 *(0.0218)*	-0.0563** *(0.0258)*
ΔOPN_{t-2}	0.0470* *(0.0262)*	0.0315 *(0.0225)*	0.0467* *(0.0264)*	0.0308 *(0.0220)*	0.0458* *(0.0266)*
HUM_{t-1}	0.7935*** *(0.3066)*	0.3059 *(0.2324)*	1.0230*** *(0.3086)*	0.5376** *(0.2375)*	0.7910** *(0.3097)*
INF_{t-1}	0.0007 *(0.0355)*	-0.0307 *(0.0349)*	0.0603* *(0.0360)*	0.0306 *(0.0318)*	0.0103 *(0.0339)*
$Cons$	0.6186*** *(0.0751)*	0.3947*** *(0.0588)*	0.5962*** *(0.0777)*	0.3528*** *(0.0597)*	0.6210*** *(0.0769)*
Time fixed effect	No	Yes	No	Yes	No
Wooldridge test for autocorrelation	$F(1,8)$=69.071 Prob>F=0.0000	$F(1,8)$=131.412 Prob>F=0.0000	$F(1,8)$=70.404 Prob>F=0.0000	$F(1,8)$=146.566 Prob>F=0.0000	$F(1,8)$=68.415 Prob>F=0.0000
AR(1) specification	Yes	Yes	Yes	Yes	Yes
No. of Obs	175	175	175	176	171
R-squared	0.4235	0.8064	0.3904	0.8291	0.3827
Ward test for model specification	$\chi^2(2)$ = 208.35 Prob>χ^2=0.0000	$\chi^2(2)$ =3.38e+09 Prob>χ^2=0.0000	$\chi^2(2)$ = 253.83 Prob>χ^2=0.0000	$\chi^2(2)$ =5.47e+10 Prob>χ^2=0.0000	$\chi^2(2)$ = 177.36 Prob>χ^2=0.0000

Table 8.8: PCSE regression of $\mathrm{TFP\_DEA}$ on RER misalignments and additional covariates (cont)

$\boldsymbol{TFP\_DEA_t}$	Regression				
	(3b)	**(4a)**	**(4b)**	**(5a)**	**(5b)**
TFP_DEA_{t-1}	0.6031*** *(0.0627)*	0.3672*** *(0.0807)*	0.6322*** *(0.0650)*	0.4036*** *(0.0767)*	0.6750*** *(0.0555)*
$MIS3_{t-1}$	0.0450*** *(0.0142)*				
$MIS4_{t-1}$		0.0240* *(0.0127)*	0.0227* *(0.0121)*		
$MIS5_{t-1}$				0.0131 *(0.0159)*	0.0288** *(0.0120)*
FDI_{t-1}	-0.0304 *(0.0484)*	0.0128 *(0.0583)*	-0.0388 *(0.0471)*	0.0052 *(0.0573)*	-0.0435 *(0.0463)*
FDI_{t-2}	-0.1729*** *(0.0592)*	-0.2385*** *(0.0654)*	-0.1799*** *(0.0570)*	-0.2284*** *(0.0648)*	-0.1690*** *(0.0575)*
FDI_{t-3}	0.2213*** *(0.0509)*	0.2201*** *(0.0609)*	0.2188*** *(0.0495)*	0.2368*** *(0.0607)*	0.2300*** *(0.0484)*
ΔGOV_{t-1}	0.8218*** *(0.2456)*	1.0160*** *(0.2835)*	0.7343*** *(0.2486)*	1.0498*** *(0.2837)*	0.7892*** *(0.2412)*
AGR_{t-1}	-0.0419* *(0.0231)*	-0.1160*** *(0.0279)*	-0.0492** *(0.0242)*	-0.1013*** *(0.0270)*	-0.0319 *(0.0229)*
ΔDCB_{t-1}	0.0412 *(0.0292)*	0.0256 *(0.0357)*	0.0455 *(0.0289)*	0.0249 *(0.0357)*	0.0466* *(0.0282)*
ΔDCP_{t-1}	-0.0726** *(0.0353)*	-0.0981** *(0.0441)*	-0.0784** *(0.0346)*	-0.0988** *(0.0437)*	-0.0819** *(0.0333)*

ΔOPN_{t-1}	-0.0163 *(0.0223)*	-0.0586** *(0.0258)*	-0.0141 *(0.0219)*	-0.0610** *(0.0261)*	-0.0149 *(0.0216)*
ΔOPN_{t-2}	0.0270 *(0.0223)*	0.0468* *(0.0266)*	0.0288 *(0.0218)*	0.0453* *(0.0267)*	0.0249 *(0.0215)*
HUM_{t-1}	0.2835 *(0.2158)*	0.9379*** *(0.3103)*	0.4591** *(0.2199)*	0.9439*** *(0.3109)*	0.3621 *(0.2235)*
INF_{t-1}	-0.0229 *(0.0329)*	0.0360 *(0.0333)*	0.0027 *(0.0321)*	0.0538 *(0.0356)*	-0.0039 *(0.0284)*
$Cons$	0.3571*** *(0.0587)*	0.6108*** *(0.0788)*	0.3491*** *(0.0609)*	0.5821*** *(0.0796)*	0.2993*** *(0.0567)*
Time fixed effect	Yes	No	Yes	No	Yes
Wooldridge test for autocorrelation	$F(1,8)$=133.580 Prob>F=0.0000	$F(1,8)$=73.425 Prob>F=0.0001	$F(1,8)$=142.591 Prob>F=0.0000	$F(1,8)$=73.208 Prob>F=0.0000	$F(1,8)$=146.563 Prob>F=0.0000
AR(1) specification	Yes	Yes	Yes	Yes	Yes
No. of Obs	171	171	171	171	171
R-squared	0.8361	0.3684	0.8296	0.3616	0.8587
Ward test for model specification	$\chi^2(2)$ = 3.24e+08 Prob>χ^2=0.0000	$\chi^2(2)$ =208.24 Prob>χ^2=0.0000	$\chi^2(2)$ = 3.11e+08 Prob>χ^2=0.0000	$\chi^2(2)$ = 194.32 Prob>χ^2=0.0000	$\chi^2(2)$ = 1.50e+08 Prob>χ^2=0.0000

Note: ****, ** and * indicate significance at 1%, 5% and 10%, respectively.*

Source: The author

8.5 Conclusion

Chapter 8 studies the productivity channel through which the RER misalignment might affect economic growth. The effect of the RER misalignment on TFP growth is empirically examined. This study takes into consideration two alternative measures of TFP, which are derived from the primal growth accounting method and the non-parametric DEA method. Overall, the empirical evidence supports a positive role of a depreciated RER in promoting TFP growth.

The PCSE estimator indicates that four out of the five RER misalignment indices, $MIS1$, $MIS3$, $MIS4$ and $MI5$, have positive and statistically significant effects on the TFP growth in the baseline models. This result is consistent among regressions using alternative measures of TFP growth rate. $MIS2$ is the only RER misalignment index that does not have statistically significant correlation with measures of TFP growth. Nevertheless, the coefficients of the RER misalignment indices are always positive in the baseline regressions. The effect of the RER misalignment on TFP growth is sizable. In the TFP_GA models, a 10 percent depreciation in the RER causes the TFP growth rate to increase from 2.89 to 5.38 percentage points. In the TFP_DEA model, a 10 percent depreciation in the RER causes the TFP growth rate increase from 2.18 to 4.62 percentage points. The effect of the RER misalignment on TFP growth is confirmed by the robustness tests in which additional covariates are added into the baseline models. The extended models demonstrate fairly similar results to the baseline models. With the exception of $MIS2$, all other RER misalignment indices are found to have positive effect on TFP growth in model using additional covariates.

The empirical evidence provided in this chapter is in line with previous studies such as Mbaye (2012) and McLeod and Mileva (2011), who also found the positive correlation between the RER misalignment and TFP growth in other country samples. This study supplements the literature in several ways. Firstly, it is the very first study focusing on the relationship between the RER misalignment and TFP in the fairly small and homogenous sample of the high performing East Asian countries, having similar features in terms of geography, intra-regional trade, and intra-regional investment. The empirical evidence in this research could complement and confirm evidence provided by large country panel or single country time series studies. Secondly, this study makes use of various approaches to estimate TFP and the RER misalignment to increase the robustness of the empirical results. This estimation strategy could reduce the severity of measurement errors as theory does not provide precise instruction on methods to measure TFP and the RER misalignment.

Finally, it should be noted that the DEA method does not provide statistical underpinning to the estimated efficiencies. In further research, the bootstrapping DEA technique could be applied for cross-checking purposes.

CHAPTER 9

CONCLUSION

9.1 Summary and contribution of the thesis

This thesis has examined theoretically and empirically the channels through which the RER misalignment affects economic growth in developing countries. While the literature has not achieved a consensus on the concept of the RER misalignment (see Chapter 2), this thesis adopts the medium-term approach to define the RER misalignment rather than creating a new concept of the RER misalignment.

In Chapter 2, a review of the literature shows that there is much uncertainty in measuring the RER misalignment due to measurement errors in estimations of the RER and the ERER. This prompts recommendations that empirical studies should invest concerted effort in ensuring the accuracy of RER misalignment estimation in order to improve the robustness of empirical evidence.

Chapter 3 reviews theoretical and empirical literature on the growth effect of the RER misalignment. In general, theoretical understanding on the effect of the RER misalignment on economic growth is just at an early stage (P. Montiel & Serven, 2008). While the negative growth effect of overvaluation appears to be obvious, more attention is needed on the relationship between undervaluation and economic growth. Literature suggests two main explanations for the growth-enhancing effect of undervaluation. The first hypothesis emphasises the externalities of undervaluation, which could move an economy toward its optimal state. The second hypothesis highlights the role of undervaluation in releasing a developing country’s balance of payments constraint. Although there are a large number of empirical studies documenting the evidence for the positive effect of undervaluation on economic growth, the validity of those studies has been challenged by recent studies. Notably, the equation-based approach to estimate the RER tends to exaggerate the correlation between the RER misalignment and economic growth (Henry & Woodford, 2008). Moreover, the correlation of the RER misalignment and economic growth turns out to be insignificant after addressing the endogeneity issue and the misleading averaging problem in constructing an undervaluation index (i.e. Nouira & Sekkat, 2012; Schroder, 2013)

Chapter 4 and Chapter 5 attempt to explain the investment channel of the growth-enhancing effect of undervaluation. Chapter 4 theoretically examines the effect of an RER depreciation on investment in an intertemporal model. It is found that a depreciation in the RER results in higher levels of steady state capital stock and investment. Moreover, a depreciation in the RER increases the optimal investment rate associated with any initial capital stock. Since previous studies mostly rely on Keynesian economics to analyse the short-run effect of a depreciated RER, this study supplements the literature by adopting a neoclassical economic setting to model the dynamic role of a depreciated RER in the long-run. Chapter 5 calibrates the theoretical model developed in Chapter 4, using model parameters representing a typical middle-income economy. Two calibrations have been carried out using different assumptions on the form of the tradables production function. In the benchmark models, the investment enhancing effect of a RER depreciation is found to be sizable.

Chapter 6 analyses distinctive features of developing East Asian economies such as high economic performance, strong intra-regional trade and financial linkages, and export-led growth strategies. It goes on to describe the empirical algorithms used to estimate six alternative RER misalignment indices. Estimated indices of the RER misalignment are found to be highly correlated to each other, especially between indices derived from the same method or price index.

Chapter 7 provides empirical analysis of the relationship between the RER misalignment, financial integration and economic growth in the developing East Asian economies. It first regresses economic growth on the RER misalignment indices estimated in Chapter 6 and finds that undervaluation (overvaluation) has positive (negative) effect on economic growth.

Subsequently, it examines the interaction between the RER misalignment and financial integration and finds that the growth-enhancing effect of undervaluation is strengthened by a lower degree of financial integration. This means that a less financially integrated economy could benefit more from an undervalued exchange rate than a highly financially integrated economy. This finding has policy implications, being that a competitive exchange rate policy may be not appropriate for all developing countries since its effectiveness is largely subject to economic conditions such as the degree of financial integration.

Chapter 7 could significantly contribute to the existing literature. Firstly. this chapter provides an in-depth study on the relationship between the RER misalignment and economic growth. It estimates the correlation between the RER misalignment, financial integration and economic growth using a variety of estimations of the RER misalignment and proxies of financial integration in order to avoid a misleading result caused by measurement errors. Secondly, it is the very first study to sample a distinct group of developing East Asian economies. The empirical result derived from the PCSE estimator, which is compatible with a long time-series dimension panel, could complement the current body of the empirical literature, which mostly comprise studies using the GMM estimator. Finally, the distinguished contribution of this study is that it explores and confirms the role of financial integration in determining the relationship between the RER misalignment and economic growth.

Chapter 8 examines empirically the productivity channel of the RER misalignment and economic growth linkage. It estimates TFP growth in the developing East Asian economies by two alternative methods: growth accounting; and DEA, and then regresses TFP growth on the RER misalignment indices estimated in Chapter 6. It finds significant evidence to support that a depreciated RER could promote TFP growth. Moreover, the effect of the RER misalignment on TFP growth is found to be sizable. This study advances the existing literature because it thoroughly and comprehensively investigates the correlation between productivity and the RER misalignment. The empirical result undergoes rigorous scrutiny in which a variety of estimations of TFP growth and the RER misalignment are investigated in the regression models. Moreover, Chapter 8 provides the first evidence of the effect of the RER misalignment on TFP growth in the high performing East Asian economies, which could be valuable in complementing and confirming single-country time series and large cross-section dimension panel studies.

9.2 Limitations and suggestions for further research

One of the main limitations in the theoretical analysis section of this thesis is the negligence of the role of government in the model. Therefore, the RER is only considered as an exogenous variable in the analysis framework rather than a policy-target variable. It is well-known that the RER could be identified by a number of factors such as supply shocks (e.g. advances in productivity of the tradables sector), demand shocks (e.g. changes in consumption preference) and government policies. While the model setting can capture the impact of the RER movements caused by supply and demand shocks, it has limitation in analysing the impact of an RER depreciation originating from government intervention since each government policy is often accompanied by its own side effects. For example, a competitive exchange rate targeting policy may require adjustment in the interest rate level, which also affects investment.

It is recommended that further research incorporates the role of government into the model. On the one hand, this would help capture the side effect of exchange rate targeting policy on investment and hence provide a more comprehensive analysis on the linkage between the RER and investment. On the other hand, incorporating government into the model setting would make the analysis framework more complicated and the intertemporal optimising system could be too cumbersome to solve. However, the dynamic stochastic partial equilibrium and general equilibrium frameworks could be considered in that case. Notably, in order to make the intertemporal maximising system solvable, Chapter 8 employs an univariate investment cost function despite there being are more adherents of a multivariate form, being that investment cost is a function of investment level and capital stock, in the literature (for example, see Barro & Martin, 1995; Shioji, 2001). However, the univariate investment cost function is recommended to be employed in the dynamic stochastic partial equilibrium and general equilibrium models.

Moreover, the nexus between the RER and social welfare would be worth-study. Since economic growth does not necessarily lead to social welfare benefits, analysing the impact of the RER on investment and economic growth might be limited in providing policy implementation. An instance is the China's undervalued currency policy, which has been criticised for imposing social cost in maintaining a large amount of international reserves.

Chapter 7 of this thesis made use of a sample consisting of East Asian economies and found that financial integration plays an important role in determining the relationship between the RER misalignment and economic growth. In further research, it is necessary to examine the relationship between financial integration, the RER misalignment and economic growth using different samples. Special interest could be focused on whether this relationship widely exists in all countries or it is a special feature of East Asian economies. In particular, this relationship could be examined using the GMM estimator for a panel consisting of a large number of countries. Also, the framework of this study could be replicated in other economic regions to find new evidence on the interaction effect of financial integration and the RER misalignment.

Similarly, research on the productivity channel through which the RER misalignment affects economic growth is in an early stage and more effort should be channelled into seeking new evidence of this relationship in other economic regions. Moreover, as the DEA method applied in Chapter 8 does not provide statistical underpinning to the estimated efficiencies, the bootstrapping DEA technique could be considered for cross-checking purposes in further research.

APPENDIX A: REGRESSIONS OF THE GROWTH MODEL WITHOUT FDI USED AS A CONTROL VARIABLE.

Table 1A: Regressions using $MIS1$ index, without FDI used as a control variable

	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
$GDPG_{t-1}$	0.4951*** *(0.0759)*	0.5000*** *(0.0750)*	0.4947*** *(0.0728)*	0.3657*** *(0.0677)*	0.4278*** *(0.0645)*	0.5150*** *(0.0708)*
$MIS1_{t-1}$	0.0225** *(0.0103)*	0.0304** *(0.0120)*	0.0306** *(0.0138)*	-0.0129 *(0.0153)*	0.0186* *(0.0095)*	0.0191 *(0.0156)*
Financial integration proxies and interaction terms						
FDI_{t-1}	-0.0303 *(0.0305)*	0.1132 *(0.1248)*				
$(MIS1 * FDI)_{t-1}$		-0.1497 *(0.1382)*				
FOP_{t-1}			0.0083 *(0.0074)*			
$(MIS1 * FOP)_{t-1}$			-0.0090 *(0.0075)*			
L				-0.1092** *(0.0554)*	-0.0837 *(0.0523)*	
$(MIS1 * L)_{t-1}$				0.1257** *(0.0499)*	0.0947** *(0.0470)*	
H				-0.0415** *(0.0191)*		-0.0120 *(0.0194)*
$(MIS1 * H)_{t-1}$				0.0495** *(0.0198)*		0.0138 *(0.0201)*

Control variables						
GOV_{t-1}	0.1679** *(0.0707)*	0.2008*** *(0.0633)*	0.1909*** *(0.0653)*	0.1278** *(0.0600)*	0.1185** *(0.0564)*	0.1961*** *(0.0698)*
INF_{t-1}	-0.0478 *(0.0357)*	-0.0690** *(0.0343)*	-0.0750** *(0.0332)*	-0.0389 *(0.0351)*	-0.0656* *(0.0336)*	-0.0304 *(0.0364)*
INF_{t-2}	0.0325 *(0.0334)*	0.0461* *(0.0275)*	0.0433 *(0.0272)*	0.0188 *(0.0328)*	0.0137 *(0.0322)*	0.0380 *(0.0336)*
FCF_{t-1}	0.0492 *(0.0391)*	0.0604 *(0.0373)*	0.0719** *(0.0363)*	0.0179 *(0.0388)*	0.0356 *(0.0360)*	0.0391 *(0.0399)*
$Intercept$	-0.0438** *(0.0169)*	-0.0463*** *(0.0143)*	-0.0538*** *(0.0147)*	0.0103 *(0.0177)*	-0.0216* *(0.0127)*	-0.0352* *(0.0180)*
Time fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Wooldridge test for autocorrelation	F(1,8)=207.649 Prob>F=0.0000	F(1,8)=207.076 Prob>F=0.0000	F(1,8)=179.133 Prob>F=0.0000	F(1,8)=201.295 Prob>F=0.0000	F(1,8)=253.834 Prob>F=0.0000	F(1,8)=202.365 Prob>F=0.0000
AR(1) specification	Yes	Yes	Yes	Yes	Yes	Yes
No. of Observations	283	283	311	341	341	341
R-squared	0.6459	0.6496	0.6246	0.6444	0.6418	0.6275

Note: When AR(1) process of error is specified, the coefficients were estimated by Prais–Winsten regression.
Standard errors are presented in parentheses.
****, ** and * indicate significance at 1%, 5% and 10%, respectively.*
Dependent variable: growth rate of per capita output.
Source: The author

Table 2A: Regressions using $MIS2$ index, without FDI used as a control variable

	(1)	(2)	(3)	(4)	(5)	(6)
$GDPG_{t-1}$	0.4847*** *(0.0763)*	0.4890*** *(0.0755)*	0.4812*** *(0.0737)*	0.3805*** *(0.0690)*	0.4116*** *(0.0659)*	0.5156*** *(0.0708)*
$MIS2_{t-1}$	0.0199** *(0.0099)*	0.0282*** *(0.0106)*	0.0234** *(0.0091)*	0.0042 *(0.0124)*	0.0137* *(0.0075)*	0.0246* *(0.0126)*
Financial integration proxies and interaction terms						
FDI_{t-1}	-0.0415 *(0.0310)*	0.1113 *(0.0989)*				
$(MIS2 * FDI)_{t-1}$		-0.1445 *(0.0948)*				
FOP_{t-1}			0.0059 *(0.0053)*			
$(MIS2 * FOP)_{t-1}$			-0.0073 *(0.0052)*			
L				-0.0916 *(0.0576)*	-0.0910 *(0.0569)*	
$(MIS2 * L)_{t-1}$				0.1104** *(0.0538)*	0.1039** *(0.0528)*	
H				-0.0014 *(0.0160)*		0.0122 *(0.0156)*
$(MIS2 * H)_{t-1}$				0.0094 *(0.0167)*		-0.0107 *(0.0161)*
Control variables						

GOV_{t-1}	0.1833*** *(0.0657)*	0.1942*** *(0.0643)*	0.1498** *(0.0649)*	0.1289** *(0.0580)*	0.1076* *(0.0556)*	0.1642** *(0.0653)*
INF_{t-1}	-0.0688* *(0.0352)*	-0.0749** *(0.0347)*	-0.0529 *(0.0370)*	-0.0515 *(0.0350)*	-0.0645* *(0.0348)*	-0.0473 *(0.0376)*
INF_{t-2}	0.0390 *(0.0280)*	0.0385 *(0.0276)*	0.0209 *(0.0341)*	0.0132 *(0.0329)*	0.0104 *(0.0328)*	0.0261 *(0.0345)*
FCF_{t-1}	0.0704* *(0.0363)*	0.0690* *(0.0359)*	0.0559 *(0.0387)*	0.0274 *(0.0383)*	0.0468 *(0.0359)*	0.0545 *(0.0391)*
$Intercept$	-0.0359*** *(0.0131)*	-0.0425*** *(0.0129)*	-0.0337*** *(0.0112)*	-0.0080 *(0.0145)*	-0.0164 *(0.0108)*	-0.0397*** *(0.0137)*
Time fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Wooldridge test for autocorrelation	F(1,8)=223.162 Prob>F=0.0000	F(1,8)=224.797 Prob>F=0.0000	F(1,8)=209.397 Prob>F=0.0000	F(1,8)=312.619 Prob>F=0.0000	F(1,8)=310.109 Prob>F=0.0000	F(1,8)=295.424 Prob>F=0.0000
AR(1) specification	Yes	Yes	Yes	Yes	Yes	Yes
No. of Observations	283	283	311	341	341	341
R-squared	0.6439	0.6477	0.6225	0. 6374	0. 6348	0.6217

Note: When AR(1) process of error is specified, the coefficients were estimated by Prais–Winsten regression.
Standard errors are presented in parentheses.
****, ** and * indicate significance at 1%, 5% and 10%, respectively.*
Dependent variable: growth rate of per capita output.
Source: The author

Table 3A: Regressions using MIS3 index, without FDI used as a control variable

	(1)	(2)	(3)	(4)	(5)	(6)
$GDPG_{t-1}$	0.4762*** (0.0789)	0.4746*** (0.0768)	0.3932*** *(0.0773)*	0.3487*** *(0.0772)*	0.3524*** *(0.0763)*	0.4660*** *(0.0770)*
$MIS3_{t-1}$	0.0209* (0.0120)	0.0386*** (0.0139)	0.0640*** *(0.0142)*	0.0035 *(0.0169)*	0.0062 *(0.0133)*	0.0404*** *(0.0146)*
Financial integration proxies and interaction terms						
FDI_{t-1}	-0.0347 (0.0317)	0.2404* (0.1299)				
$(MIS3 * FDI)_{t-1}$		-0.2832** (0.1427)				
FOP_{t-1}			0.0299*** *(0.0082)*			
$(MIS3 * FOP)_{t-1}$			-0.0307*** *(0.0083)*			
L				-0.0998** *(0.0462)*	-0.1025** *(0.0423)*	
$(MIS3 * L)_{t-1}$				0.1154*** *(0.0438)*	0.1157*** *(0.0400)*	
H				0.0034 *(0.0219)*		0.0389** *(0.0215)*
$(MIS3 * H)_{t-1}$				0.0006 *(0.0236)*		-0.0406* *(0.0233)*
Control variables						

GOV_{t-1}	0.1840*** (0.0694)	0.1904*** (0.0668)	0.1633** *(0.0665)*	0.1239** *(0.0581)*	0.1224** *(0.0577)*	0.1915*** *(0.0648)*
INF_{t-1}	-0.0574 (0.0352)	-0.0696** (0.0349)	-0.0934*** *(0.0343)*	-0.0805** *(0.0348)*	-0.0856** *(0.0338)*	-0.0740** *(0.0361)*
INF_{t-2}	0.0558** (0.0268)	0.0559** (0.0264)	0.0651** *(0.0265)*	0.0424 *(0.0260)*	0.0402 *(0.0260)*	0.0616** *(0.0265)*
FCF_{t-1}	0.0758* (0.0399)	0.0806** (0.0401)	0.1215*** *(0.0415)*	0.0638 *(0.0414)*	0.0718* *(0.0393)*	0.0883** *(0.0422)*
$Intercept$	-0.0395** (0.0156)	-0.0574*** (0.0169)	-0.0903*** *(0.0180)*	-0.0137 *(0.0201)*	-0.0162 *(0.0169)*	-0.0645*** *(0.0170)*
Time fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Wooldridge test for autocorrelation	F(1,8)=121.434 Prob>F=0.0000	F(1,8)=111.006 Prob>F=0.0000	F(1,8)=121.073 Prob>F=0.0000	F(1,8)=132.331 Prob>F=0.0000	F(1,8)=125.837 Prob>F=0.0000	F(1,8)=127.282 Prob>F=0.0000
AR(1) specification	Yes	Yes	Yes	Yes	Yes	Yes
No. of Observations	240	240	240	240	240	240
R-squared	0.6623	0.6698	0.6776	0.6824	0.6814	0.6657

Note: When AR(1) process of error is specified, the coefficients were estimated by Prais–Winsten regression.
Standard errors are presented in parentheses.
****, ** and * indicate significance at 1%, 5% and 10%, respectively.*
Dependent variable: growth rate of per capita output.
Source: The author

Table 4A: Regressions using $MIS4$ index, without FDI used as a control variable

	(1)	(2)	(3)	(4)	(5)	(6)
$GDPG_{t-1}$	0.4682*** (0.0789)	0.4632*** (0.0778)	0.4094*** *(0.0766)*	0.3619*** *(0.0757)*	0.3734*** *(0.0761)*	0.4328*** *(0.0760)*
$MIS4_{t-1}$	0.0263** (0.0117)	0.0403*** (0.0127)	0.0503*** *(0.0126)*	0.0205 *(0.0149)*	0.0075 *(0.0121)*	0.0548*** *(0.0164)*
Financial integration proxies and interaction terms						
FDI_{t-1}	-0.0392 (0.0314)	0.1816 (0.1129)				
$(MIS4 * FDI)_{t-1}$		-0.2160* (0.1121)				
FOP_{t-1}			0.0187*** *(0.0071)*			
$(MIS4 * FOP)_{t-1}$			-0.0202*** *(0.0071)*			
L				-0.0916** *(0.0402)*	-0.1056*** *(0.0395)*	
$(MIS4 * L)_{t-1}$				0.1052*** *(0.0375)*	0.1173*** *(0.0373)*	
H				0.0295 *(0.0234)*		0.0543** *(0.0239)*
$(MIS4 * H)_{t-1}$				-0.0264 *(0.0248)*		-0.0568** *(0.0257)*
Control variables						

GOV_{t-1}	0.1891*** (0.0703)	0.1904*** (0.0668)	0.1532** *(0.0700)*	0.1188* *(0.0626)*	0.1113* *(0.0627)*	0.2075*** *(0.0668)*
INF_{t-1}	-0.0660* (0.0353)	-0.0761** (0.0350)	-0.0846** *(0.0344)*	-0.0873*** *(0.0329)*	-0.0769** *(0.0330)*	-0.0942*** *(0.0356)*
INF_{t-2}	0.0534** (0.0268)	0.0535** (0.0266)	0.0562** *(0.0265)*	0.0446* *(0.0254)*	0.0456* *(0.0262)*	0.0562** *(0.0259)*
FCF_{t-1}	0.0887** (0.0394)	0.0915** (0.0392)	0.1154*** *(0.0407)*	0.0811** *(0.0408)*	0.0812** *(0.0397)*	0.1122*** *(0.0416)*
$Intercept$	-0.0481*** (0.0166)	-0.0613*** (0.0169)	-0.0724*** *(0.0163)*	-0.0303 *(0.0192)*	-0.0174 *(0.0179)*	-0.0815*** *(0.0198)*
Time fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Wooldridge test for autocorrelation	F(1,8)=120.255 Prob>F=0.0000	F(1,8)=121.970 Prob>F=0.0000	F(1,8)=133.684 Prob>F=0.0000	F(1,8)=124.824 Prob>F=0.0000	F(1,8)=121.782 Prob>F=0.0000	F(1,8)=127.068 Prob>F=0.0000
AR(1) specification	Yes	Yes	Yes	Yes	Yes	Yes
No. of Observations	240	240	240	240	240	240
R-squared	0.6681	0.6739	0.6751	0.6877	0.6847	0.6727

Note: A first-order autoregressive process of error was specified and the coefficients were estimated by Prais–Winsten regression.
Standard errors are presented in parentheses.
****, ** and * indicate significance at 1%, 5% and 10%, respectively.*
Dependent variable: growth rate of per capita output.
Source: The author

Table 5A: Regressions using MIS5 index, without FDI used as a control variable

	(1)	(2)	(3)	(4)	(5)	(6)
$GDPG_{t-1}$	0.4739*** *(0.0791)*	0.4737*** *(0.0788)*	0.3894*** *(0.0820)*	0.3389*** *(0.0797)*	0.3493*** *(0.0771)*	0.4665*** *(0.0798)*
$MIS5_{t-1}$	0.0256* *(0.0139)*	0.0288** *(0.0134)*	0.0548*** *(0.0140)*	-0.0024 *(0.0177)*	0.0200 *(0.0149)*	0.0126 *(0.0134)*
Financial integration proxies and interaction terms						
FDI_{t-1}	-0.0348 (0.0315)	0.0612 (0.2163)				
$(MIS5 * FDI)_{t-1}$		-0.0958 (0.2232)				
FOP_{t-1}			0.0320*** (0.0111)			
$(MIS5 * FOP)_{t-1}$			-0.0333*** (0.0112)			
L				-0.0661 (0.0471)	-0.0506 (0.0416)	
$(MIS5 * L)_{t-1}$				0.0875* (0.0448)	0.0709* (0.0395)	
H				-0.0488 (0.0339)		-0.0365 (0.0293)
$(MIS5 * H)_{t-1}$				0.0523 (0.0342)		0.0354 (0.0298)
Control variables						

GOV_{t-1}	0.1718** (0.0683)	0.1749*** (0.0656)	0.1820*** (0.0653)	0.1499*** (0.0542)	0.1524*** (0.0547)	0.1923*** (0.0645)
INF_{t-1}	-0.0629* (0.0355)	-0.0639* (0.0355)	-0.0817** (0.0345)	-0.0775** (0.0350)	-0.0957*** (0.0340)	-0.0485 (0.0357)
INF_{t-2}	0.0562** (0.0268)	0.0570** (0.0269)	0.0690** (0.0275)	0.0429 (0.0265	0.0398 (0.0257)	0.0669** (0.0273)
FCF_{t-1}	0.0769* (0.0404)	0.0781* (0.0413)	0.1210*** (0.0438)	0.0598 (0.0435)	0.0606 (0.0417)	0.0815* (0.0426)
$Intercept$	-0.0430*** (0.0167)	-0.0467*** (0.0160)	-0.0829*** (0.0178)	-0.0104 (0.0186)	-0.0304* (0.0165)	-0.0379** (0.0158)
Time fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Wooldridge test for autocorrelation	F(1,8)=122.786 Prob>F=0.0000	F(1,8)=124.308 Prob>F=0.0000	F(1,8)=123.646 Prob>F=0.0000	F(1,8)=118.998 Prob>F=0.0000	F(1,8)=124.218 Prob>F=0.0000	F(1,8)=117.987 Prob>F=0.0000
AR(1) specification	Yes	Yes	Yes	Yes	Yes	Yes
No. of Observations	240	240	240	240	240	240
R-squared	0.6610	0.6617	0.6730	0.6804	0.6777	0.6599

Note: A first-order autoregressive process of error was specified and the coefficients were estimated by Prais–Winsten regression.
Standard errors are presented in parentheses.
****, ** and * indicate significance at 1%, 5% and 10%, respectively.*
Dependent variable: growth rate of per capita output.
Source: The author

REFERENCES

Acemoglu, D., Johnson, S., Robinson, J., & Thaicharoen, Y. (2003). Institutional causes, macroeconomic symptoms: volatility, crises and growth. *Journal of Monetary Economics, 50*(1), 49-123.

Aghion, P., Bacchetta, P., Rancière, R., & Rogoff, K. (2009). Exchange rate volatility and productivity growth: The role of financial development. *Journal of Monetary Economics, 56*(4), 494-513. doi: http://dx.doi.org/10.1016/j.jmoneco.2009.03.015

Aghion, P., Howitt, P., & Mayer, D. (2005). The Effect of Financial Development on Convergence. *Quarterly Journal of Economics*.

Aguirre, A., & Calderon, C. A. (2005). Real Exchange Rate Misalignments and Economic Performance: Central Bank of Chile.

Akaike, H. (1974). A new look at the statistical model identification. *Automatic Control, IEEE Transactions on, 19*(6), 716-723.

Alberola Ila, E., Garcia Cervero, S., Lopez, J. H., & Ubide, A. J. (1999). *Global Equilibrium Exchange Rates-Euro, Dollar," Ins,"" Outs," and Other Major Currencies in a Panel Cointegration Framework*: International Monetary Fund.

Alejandro, C. F. D. (1963). A Note on the Impact of Devaluation and the Redistributive Effect. *The Journal of Political Economy*, 577-580.

Alper, A. M., & Civcir, İ. (2012). Can overvaluation prelude to crisis and harm growth in Turkey. *Journal of Policy Modeling, 34*(1), 112-131.

Arellano, M., & Bover, O. (1995). Another look at the instrumental variable estimation of error-components models. *Journal of Econometrics, 68*(1), 29-51.

Artus, J. R. (1978). Methods of assessing the long-run equilibrium value of an exchange rate. *Journal of International Economics, 8*(2), 277-299.

Artus, J. R., & Knight, M. D. (1984). *Issues in the assessment of the exchange rates of industrial countries*: International Monetary Fund.

Bai, C.-E., Hsieh, C.-T., & Qian, Y. (2006). The Return to Capital in China. *Brookings Papers on Economic Activity, 2006*(2), 61-101.

Balassa, B. (1964). The purchasing-power parity doctrine: a reappraisal. *The Journal of Political Economy, 72*(6), 584-596.

Barisone, G., Driver, R. L., & Wren-Lewis, S. (2006). Are our FEERs justified? *Journal of International Money and Finance, 25*(5), 741-759.

Barro, R., & Martin, S.-i. (1995). X., 1995. Economic growth. *Boston, MA*.

Basu, S., & Fernald, J. G. (1997). Returns to scale in US production: Estimates and implications. *Journal of Political Economy, 105*(2), 249-283.

Battese, G. E., & Coelli, T. J. (1995). A model for technical inefficiency effects in a stochastic frontier production function for panel data. *Empirical Economics, 20*(2), 325-332.

Baumol, W. J., & Bowen, W. G. (1966). Performing Arts-The Economic Dilemma: A Study of Problems Common to Theater. *Opera, Music, and Dance (New York: Twentieth Century Fund, 1966)*.

Baxter, M., & King, R. G. (1999). Measuring business cycles: approximate band-pass filters for economic time series. *Review of Economics and Statistics, 81*(4), 575-593.

Bayoumi, T., Clark, P., Symansky, S., & Taylor, M. (1994). The robustness of equilibrium exchange rate calculations to alternative assumptions and methodologies. In J. Williamson (Ed.), *Estimating equilibrium exchange rates* (pp. 19-60).

Beck, N. L., & Katz, J. N. (1995). What to do (and not to do) with time-series cross-section data. *American political science review, 89*(3), 634-647.

Bereau, S., Villavicencio, A. L., & Mignon, V. (2012). Currency misalignments and growth: a new look using nonlinear panel data methods. *Applied Economics, 44*(27), 3503-3511.

Beveridge, S., & Nelson, C. R. (1981). A new approach to decomposition of economic time series into permanent and transitory components with particular attention to measurement of the 'business cycle'. *Journal of Monetary Economics, 7*(2), 151-174.

Bhalla, S. S. (2007). Second Among Equals: The Middle Class Kingdoms of India and China: Washington: Peterson Institute for International Economics.

Black, S. W. (1994). On the concept and usefulness of the equilibrium rate of exchange. In J. Williamson (Ed.), *Estimating equilibrium exchange rates* (pp. 279-292).

Bleaney, M., & Greenaway, D. (2001). The impact of terms of trade and real exchange rate volatility on investment and growth in sub-Saharan Africa. *Journal of Development Economics, 65*(2), 491-500. doi: http://dx.doi.org/10.1016/S0304-3878(01)00147-X

Blecker, R. A., & Razmi, A. (2008). The fallacy of composition and contractionary devaluations: output effects of real exchange rate shocks in semi-industrialised countries. *Cambridge Journal of economics, 32*(1), 83-109.

Blundell, R., & Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of Econometrics, 87*(1), 115-143. doi: http://dx.doi.org/10.1016/S0304-4076(98)00009-8

Bosworth, B., & Collins, S. M. (2003). The empirics of growth: An update. *Brookings Papers on Economic Activity, 2003*(2), 113-206.

Buffie, E. F. (1986). Devaluation, investment and growth in LDCs. *Journal of Development Economics, 20*(2), 361-379.

Buffie, E. F., & Won, Y. (2001). Devaluation and investment in an optimizing model of the small open economy. *European Economic Review, 45*(8), 1461-1499.

Burnside, C., Eichenbaum, M., & Rebelo, S. (1995). Capital utilization and returns to scale *NBER Macroeconomics Annual 1995, Volume 10* (pp. 67-124): MIT Press.

Calvo, G. A., Reinhart, C. M., & Végh, C. A. (1995). Targeting the real exchange rate: theory and evidence. *Journal of Development Economics, 47*(1), 97-133. doi: http://dx.doi.org/10.1016/0304-3878(95)00006-2

Campbell, J. Y., & Perron, P. (1991). Pitfalls and opportunities: what macroeconomists should know about unit roots *NBER Macroeconomics Annual 1991, Volume 6* (pp. 141-220): MIT Press.

Caselli, F., & Feyrer, J. (2007). The Marginal Product of Capital. *The Quarterly Journal of Economics, 122*(2), 535-568.

Cassel, G. (1922). Money and foreign exchange after 1914.

Caves, D. W., Christensen, L. R., & Diewert, W. E. (1982a). The economic theory of index numbers and the measurement of input, output, and productivity. *Econometrica: Journal of the Econometric Society*, 1393-1414.

Caves, D. W., Christensen, L. R., & Diewert, W. E. (1982b). Multilateral comparisons of output, input, and productivity using superlative index numbers. *The Economic Journal*, 73-86.

Chang, W.-Y., & Tsai, H.-F. (2006). Devaluation, Capital Formation, and the Current Account. *Open Economies Review, 17*(3), 341-357.

Cheung, Y.-W., & Lai, K. S. (1993). A fractional cointegration analysis of purchasing power parity. *Journal of Business & Economic Statistics, 11*(1), 103-112.

Chinn, M. D., & Ito, H. (2008). A new measure of financial openness. *Journal of comparative policy analysis, 10*(3), 309-322.

Clark, P. B., & MacDonald, R. (1999). Exchange Rates and Economic Fundamentals: A Methodological Comparison of Beers and Feers. In R. MacDonald & J. Stein (Eds.), *Equilibrium Exchange Rates* (Vol. 69, pp. 285-322): Springer Netherlands.

Clark, P. B., & MacDonald, R. (2004). Filtering the BEER: a permanent and transitory decomposition. *Global Finance Journal, 15*(1), 29-56.

Cline, W. R. (1989). *United States external adjustment and the world economy*: Institute for International Economics Washington, DC.

Cooley, T. F. (1997). Calibrated models. *Oxford Review of Economic Policy, 13*(3), 55-69.

Cornwell, C., Schmidt, P., & Sickles, R. C. (1990). Production frontiers with cross-sectional and time-series variation in efficiency levels. *Journal of Econometrics, 46*(1), 185-200.

Cottani, J. A., Cavallo, D. F., & Khan, M. S. (1990). Real exchange rate behavior and economic performance in LDCs. *Economic development and cultural change, 39*(1), 61-76.

Cour, L. L., & MacDonald, R. (2000). Modeling the ECU against the US dollar: a structural monetary interpretation. *Journal of Business & Economic Statistics, 18*(4), 436-450.

De Gregorio, J., Giovannini, A., & Wolf, H. C. (1994). International evidence on tradables and nontradables inflation. *European Economic Review, 38*(6), 1225-1244. doi: http://dx.doi.org/10.1016/0014-2921(94)90070-1

De Gregorio, J., & Wolf, H. (1994). Terms of Trade, Productivity, and the Real Exchange Rate. *NBER Working Paper*(w4807).

Delpachitra, S., & Dai, P. V. (2012). The Determinants of TFP Growth in Middle Income Economies in ASEAN: Implication of Financial Crises. *International Journal of Business and Economics, 11*(1), 63-88.

Dollar, D. (1992). Outward-oriented developing economies really do grow more rapidly: evidence from 95 LDCs, 1976-1985. *Economic development and cultural change, 40*(3), 523-544.

Dornbusch, R. (1973). Currency depreciation, hoarding, and relative prices. *The Journal of Political Economy*, 893-915.

Dornbusch, R. (1975). Exchange Rates and Fiscal Policy in a Popular Model of International Trade. *The American Economic Review, 65*(5), 859-871. doi: 10.2307/1806625

Driver, R., & Westaway, P. (2005). Concepts of equilibrium exchange rates. In R. Driver, P. Sinclair & C. Thoenissen (Eds.), *Exchange Rates, Capital Flows and Policy*: Routledge.

Edison, H. J., & Klovland, J. T. (1987). A quantitative reassessment of the purchasing power parity hypothesis: Evidence from Norway and the United Kingdom. *Journal of applied econometrics, 2*(4), 309-333.

Edwards, S. (1988). Real and monetary determinants of real exchange rate behavior: Theory and evidence from developing countries. *Journal of Development Economics, 29*(3), 311-341.

Edwards, S. (1989). *Real exchange rates, devaluation, and adjustment: exchange rate policy in developing countries*: MIT press Cambridge, MA.

Edwards, S. (1995a). Real and Monetary Determinants of Real Exchange Rate Behavior: Theory and Evidence from Developing Countries. In J. Williamson (Ed.), *Estimating equilibrium exchange rates* (pp. 61): Washington DC: Institute for International Economics.

Edwards, S. (1995b). Why are saving rates so different across countries?: An international comparative analysis: National Bureau of Economic Research.

Egert, B., & Halpern, L. (2006). Equilibrium exchange rates in Central and Eastern Europe: A meta-regression analysis. *Journal of Banking & Finance, 30*(5), 1359-1374.

Eichengreen, B. (2007). The real exchange rate and economic growth. *Social and Economic Studies*, 7-20.

Elbadawi, I. (1994). Estimating long-run equilibrium real exchange rates. In J. Williamson (Ed.), *Estimating equilibrium exchange rates* (pp. 93-132).

Elbadawi, I., Kaltani, L., & Schmidt-Hebbel, K. (2008). Foreign aid, the real exchange rate, and economic growth in the aftermath of civil wars. *The World Bank Economic Review, 22*(1), 113-140.

Elbadawi, I., & Soto, R. (1997). Real exchange rates and macroeconomic adjustment in Sub-Saharan Africa and other developing countries. *Journal of African Economies, 6*(3), 74-120.

Engle, R. F., & Granger, C. W. (1987). Co-integration and error correction: representation, estimation, and testing. *Econometrica: Journal of the Econometric Society*, 251-276.

Fare, R., Grosskopf, S., Norris, M., & Zhang, Z. (1994). Productivity growth, technical progress, and efficiency change in industrialized countries. *The American Economic Review*, 66-83.

Faruqee, H. (1995). Long-Run Determinants of the Real Exchange Rate: A Stock-Flow Perspective. *Staff Papers-International Monetary Fund*, 80-107.

Frankel, J. A. (1986). International capital mobility and crowding out in the US economy: imperfect integration of financial markets or of goods markets? : National Bureau of Economic Research Cambridge, Mass., USA.

Frenkel, J. A., & Rodriguez, C. A. (1975). Portfolio Equilibrium and the Balance of Payments: A Monetary Approach. *The American Economic Review, 65*(4), 674-688. doi: 10.2307/1806543

Gala, P. (2008). Real exchange rate levels and economic development: theoretical analysis and econometric evidence. *Cambridge Journal of economics, 32*(2), 273-288.

Gala, P., & Lucinda, C. R. (2006). Exchange rate misalignment and growth: old and new econometric evidence. *Revista Economia*, 165-187.

Genberg, H. (1978). Purchasing power parity under fixed and flexible exchange rates. *Journal of International Economics, 8*(2), 247-276.

Ghura, D., & Grennes, T. J. (1993). The real exchange rate and macroeconomic performance in Sub-Saharan Africa. *Journal of Development Economics, 42*(1), 155-174.

Glen, J. D. (1992). Real exchange rates in the short, medium, and long run. *Journal of International Economics, 33*(1), 147-166.

Gluzmann, P., Levy-Yeyati, E., & Sturzenegger, F. (2012). Exchange rate undervaluation and economic growth: Díaz Alejandro (1965) revisited. *Economics Letters*.

Goldstein, M., & Khan, M. S. (1985). Chapter 20 Income and price effects in foreign trade. In W. J. Ronald & B. K. Peter (Eds.), *Handbook of international economics* (Vol. Volume 2, pp. 1041-1105): Elsevier.

Gonzalez, A., Terasvirta, T., & Dijk, D. v. (2005). Panel smooth transition regression models: SSE/EFI Working Paper Series in Economics and Finance.

Gonzalo, J., & Granger, C. (1995). Estimation of common long-memory components in cointegrated systems. *Journal of Business & Economic Statistics, 13*(1), 27-35.

Greenwood, J., & Jovanovic, B. (1990). Financial Development, Growth, and the Distribution of Income. *The Journal of Political Economy, 98*(5 Part 1), 1076-1107.

Gregory, A. W., & Smith, G. W. (1991). Calibration as testing: Inference in simulated macroeconomic models. *Journal of Business & Economic Statistics, 9*(3), 297-303.

Hall, A. (1994). Testing for a unit root in time series with pretest data-based model selection. *Journal of Business & Economic Statistics, 12*(4), 461-470.

Hannan, E. J., & Quinn, B. G. (1979). The determination of the order of an autoregression. *Journal of the Royal Statistical Society. Series B (Methodological)*, 190-195.

Haque, N. U., & Montiel, P. J. (1999). Long-Run Real Exchange Rate Changes in Developing Countries: Simulations from an Econometric Model. *L. Hinkle ve PJ Montiel (der.), Exchange Rate Misalignment: Concepts and Measurement for Developing Countries. Oxford: Oxford University Press & World Bank*, 381-404.

Harberger, A. C. (1988). Perspectives on capital and technology in less-developed countries. *Estudios de Economía (Chile)*.

Harberger, A. C. (2003). *Economic growth and the real exchange rate: revisiting the Balassa-Samuelson effect.* Paper presented at the a conference organized by the Higher School of Economics, Moscow.

Hausmann, R., Pritchett, L., & Rodrik, D. (2005). Growth accelerations. *Journal of Economic Growth, 10*(4), 303-329.

Henry, P. B., & Woodford, M. (2008). The Real Exchange Rate and Economic Growth. Comments and Discussion. *Brookings Papers on Economic Activity, 2008*, 413-439. doi: 10.2307/27720405

Hicks, J. R. (1963). *The theory of wages* (Vol. 2): Macmillan London.

Hinkle, L. E., & Montiel, P. J. (1999). *Exchange rate misalignment: concepts and measurement for developing countries*: World Bank.

Hodrick, R. J., & Prescott, E. C. (1997). Postwar US business cycles: an empirical investigation. *Journal of Money, credit, and Banking*, 1-16.

Hoover, K. D. (1995). Facts and artifacts: calibration and the empirical assessment of real-business-cycle models. *Oxford Economic Papers*, 24-44.

Ibarra, C. A. (2011). Capital flows, real exchange rate, and growth constraints in Mexico. *International Review of Applied Economics, 25*(6), 653-668. doi: 10.1080/02692171.2011.557047

Im, K. S., Pesaran, M. H., & Shin, Y. (2003). Testing for unit roots in heterogeneous panels. *Journal of Econometrics, 115*(1), 53-74.

Isard, P., & Faruqee, H. (1998). *Exchange rate assessment: Extension of the macroeconomic balance approach*: International Monetary Fund.

Johansen, S. (1991). Estimation and hypothesis testing of cointegration vectors in Gaussian vector autoregressive models. *Econometrica: Journal of the Econometric Society*, 1551-1580.

Johansen, S., & Juselius, K. (1990). Maximum likelihood estimation and inference on cointegration—with applications to the demand for money. *Oxford Bulletin of Economics and Statistics, 52*(2), 169-210.

Johnson, S., Ostry, J. D., & Subramanian, A. (2010). Prospects for sustained growth in Africa: benchmarking the constraints. *IMF Staff Papers, 57*(1), 119-171.

Jorgensen, S. L., & Paldam, M. (1987). *The real exchange rates of eight latin american Countries 1946-1985: an interpretation*: Geld und Wahrung/Monetary Affairs.

Kao, C., & Chiang, M.-H. (2000). On the estimation and inference of a cointegrated regression in panel data. In B. H. Baltagi, T. B. Fomby & R. C. Hill (Eds.), *Nonstationary Panels, Panel Cointegration, and Dynamic Panels* (pp. 179-222).

Katada, S. N. (2011). Seeking a place for East Asian regionalism: challenges and opportunities under the global financial crisis. *The Pacific Review, 24*(3), 273-290.

Kim, S., & Lee, J. W. (2012). Real and financial integration in East Asia. *Review of International Economics, 20*(2), 332-349.

Krugman, P., & Taylor, L. (1978). Contractionary effects of devaluation. *Journal of International Economics, 8*(3), 445-456.

Kumbhakar, S. C. (1990). Production frontiers, panel data, and time-varying technical inefficiency. *Journal of Econometrics, 46*(1), 201-211.

Kumbhakar, S. C., Ghosh, S., & McGuckin, J. T. (1991). A generalized production frontier approach for estimating determinants of inefficiency in US dairy farms. *Journal of Business & Economic Statistics, 9*(3), 279-286.

Kydland, F. E., & Prescott, E. C. (1982). Time to build and aggregate fluctuations. *Econometrica: Journal of the Econometric Society*, 1345-1370.

Larsson, R., Lyhagen, J., & Lothgren, M. (2001). Likelihood-based cointegration tests in heterogeneous panels. *The Econometrics Journal, 4*(1), 109-142.

Leonard, D. (1981). The signs of the co-state variables and sufficiency conditions in a class of optimal control problems. *Economics Letters, 8*(4), 321-325. doi: http://dx.doi.org/10.1016/0165-1765(81)90020-3

Leonard, D., & Long, N. V. (1992). *Optimal control theory and static optimization in economics*: Cambridge University Press.

Levine, R. (1997). Financial development and economic growth: views and agenda. *Journal of economic literature*, 688-726.

Lewis, W. A. (1954). Economic development with unlimited supplies of labour. *The Manchester School, 22*(2), 139-191.

Lothian, J. R., & Taylor, M. P. (1996). Real exchange rate behavior: the recent float from the perspective of the past two centuries. *Journal of Political Economy*, 488-509.

Lucas Jr, R. E. (1976). *Econometric policy evaluation: A critique.* Paper presented at the Carnegie-Rochester conference series on public policy.

MacDonald, R. (1998). What determines real exchange rates?: The long and the short of it. *Journal of International Financial Markets, Institutions and Money, 8*(2), 117-153. doi: http://dx.doi.org/10.1016/S1042-4431(98)00028-6

Malmquist, S. (1953). Index numbers and indifference surfaces. *Trabajos de Estadistica y de Investigacion Operativa, 4*(2), 209-242.

Masson, P. R., Bayoumi, T., & Samiei, H. (1998). International evidence on the determinants of private saving. *The World Bank Economic Review, 12*(3), 483-501.

Masson, P. R., Symansky, S. A., & Meredith, G. (1990). *MULTIMOD Mark II: A Revised and Extended Model-Occa Paper* (Vol. 71): International Monetary Fund.

Matsuyama, K. (1992). Agricultural productivity, comparative advantage, and economic growth. *Journal of economic theory, 58*(2), 317-334.

Mbaye, S. (2012). *Real Exchange Rate Undervaluation and Growth: Is there a Total Factor Productivity Growth Channel?* CERDI.

McKibbin, W. J., & Sachs, J. D. (1989). The McKibbin-Sachs Global Model: Theory and Specifications: National Bureau of Economic Research.

McLeod, D., & Mileva, E. (2011). Real exchange rates and productivity growth. *Fordham University Department of Economics Discussion Paper, 4*.

Meredith, G. (1989). Intermod 2.0: Model Specification and Simulation Properties: Department of Finance Canada.

Michael, P., Nobay, A. R., & Peel, D. A. (1997). Transactions costs and nonlinear adjustment in real exchange rates; An empirical investigation. *Journal of Political Economy, 105*(4), 862-879.

Milgate, M. (1998). Equilibrium: development of the concept. In J. Eatwell, M. Milgate & P. Newman (Eds.), *The New Palgrave-A Dictionary of Economics* (pp. 179-182): Basingstoke, London: Macmillan.

MIMOSA Modelling Group. (1990). *MIMOSA: a Model of the World Economy*: CEPII.

Montiel, P., & Serven, L. (2008). Real exchange rates, saving and growth: Is there a link? *World Bank Policy Research Working Paper Series, 4636*.

Montiel, P. J. (1999a). The long-run equilibrium real exchange rate: Conceptual issues and empirical research. In L. E. Hinkle & P. Montiel (Eds.), *Exchange rate misalignment: Concepts and measurement for developing countries* (pp. 219-263).

Montiel, P. J. (1999b). Determinants of the long-run equilibrium real exchange rate: an analytical model. In L. E. Hinkle & P. Montiel (Eds.), *Exchange rate misalignment: Concepts and measurement for developing countries* (pp. 264-290).

Mundell, R. A. (1971). *Monetary theory: inflation, Interest, and growth in the world economy*: Goodyear Publishing Company Pacific Palisades, CA.

Mussa, M. (1974). A monetary approach to balance-of-payments analysis. *Journal of Money, Credit and Banking, 6*(3), 333-351.

Ndhlela, T. (2012). Implications of real exchange rate misalignment in developing countries: Theory, empirical evidence and application to growth performance in Zimbabwe. *South African Journal of Economics, 80*(3), 319-344. doi: 10.1111/j.1813-6982.2012.01323.x

Newbold, P. (1990). Precise and efficient computation of the Beveridge-Nelson decomposition of economic time series. *Journal of Monetary Economics, 26*(3), 453-457.

Niesr. (1990). *REM model manual*: London: National Institute of Economic and Social Research

Nouira, R., & Sekkat, K. (2012). Desperately seeking the positive impact of undervaluation on growth. *Journal of Macroeconomics, 34*(2), 537-552.

Nurkse, R. (1945). *Conditions of international monetary equilibrium*: International Finance Section, Department of Economics and Social Institutions, Princeton University.

Officer, L. H. (1976). The Productivity Bias in Purchasing Power Parity: An Econometric Investigation (Le biais de la productivité dans la parité des pouvoirs d'achat: étude économétrique)(El sesgo de productividad en la paridad del poder adquisitivo: Una investigación econométrica). *Staff Papers-International Monetary Fund*, 545-579.

Officer, L. H. (1982). *Purchasing power parity and exchange rates: theory, evidence and relevance*: Jai Press Greenwich, CT.

Onaran, Ö. (2004). *Life after crisis for labor and capital in the era of neoliberal globalization*: Vienna University of Economics and Business Administration.

Palma, G. (2003). Latin America during the second half of the twentieth century - From the age of ISI to the age of the end of history. In H. J. Chang (Ed.), *Rethinking development economics*. London: Anthem Press.

Pedroni, P. (1999). Critical Values for Cointegration Tests in Heterogeneous Panels with Multiple Regressors. *Oxford Bulletin of Economics and Statistics, 61*(S1), 653-670. doi: 10.1111/1468-0084.0610s1653

Pedroni, P. (2004). Panel cointegration: asymptotic and finite sample properties of pooled time series tests with an application to the PPP hypothesis. *Econometric theory*, 597-625.

Pesaran, M. H. (2004). General diagnostic tests for cross section dependence in panels: CESifo working papers.

Pesaran, M. H. (2007). A simple panel unit root test in the presence of cross-section dependence. *Journal of applied econometrics, 22*(2), 265-312.

Pesaran, M. H., Shin, Y., & Smith, R. J. (1999). Pooled mean group estimation of dynamic heterogeneous panels. *Journal of the American Statistical Association, 94*(446), 621-634.

Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of applied econometrics, 16*(3), 289-326.

Pesaran, M. H., & Smith, R. J. (1998). Structural Analysis of Cointegrating VARs. *Journal of Economic Surveys, 12*(5), 471-505. doi: 10.1111/1467-6419.00065

Pitt, M. M., & Lee, L.-F. (1981). The measurement and sources of technical inefficiency in the Indonesian weaving industry. *Journal of Development Economics, 9*(1), 43-64. doi: http://dx.doi.org/10.1016/0304-3878(81)90004-3

Porcile, G., & Lima, G. T. (2010). Real exchange rate and elasticity of labour supply in a balance-of-payments-constrained macrodynamics. *Cambridge Journal of economics, 34*(6), 1019-1039.

Prais, S. J., & Winsten, C. B. (1954). Trend estimators and serial correlation: Cowles Commission discussion paper.

Prasad, E. S., Rajan, R. G., & Subramanian, A. (2007). Foreign capital and economic growth. *Brookings Papers on Economic Activity*, 153+.

Prema-chandra, A., & Kohpaiboon, A. (2009). Intra-regional trade in East Asia: The decoupling fallacy, crisis and policy challenges: ADBI Working Paper Series.

Qian, Z., & Zhu, X. (2012). Misallocation or Mismeasurement? Factor Income Shares and Factor Market Distortions in China's Manufacturing Industries: Working paper, University of Toronto.

Rajan, R. G., & Subramanian, A. (2011). Aid, Dutch disease, and manufacturing growth. *Journal of Development Economics, 94*(1), 106-118.

Rajan, R. S. (2008). Intra-Developing Asia FDI Flows: Magnitudes, Trends and Determinants. In H. Soesastro (Ed.), *Deepening Economic Integration-The ASEAN Economic Community and Beyond-* (pp. 204-238): ERIA Research Project Report 2007-1-2, Chiba: IDE-JETRO.

Rapetti, M., Skott, P., & Razmi, A. (2012). The real exchange rate and economic growth: are developing countries different? *International Review of Applied Economics, 26*(6), 735-753. doi: 10.1080/02692171.2012.686483

Razin, O., & Collins, S. M. (1999). Real-Exchange-Rate Misalignments and Growth. *The Economics of Globalization: Policy Perspectives from Public Economics*, 59.

Razmi, A., Rapetti, M., & Skott, P. (2012). The real exchange rate and economic development. *Structural Change and Economic Dynamics, 23*(2), 151-169.

Richardson, P. (1988). The structure and simulation properties of OECD's INTERLINK model. *OECD Economic Studies, 10*, 57-122.

Richardson, P. (1990). Simulating the OECD INTERLINK model under alternative monetary policy rules: OECD Publishing.

Rodrik, D. (2008). The real exchange rate and economic growth. *Brookings Papers on Economic Activity, 2008*(2), 365-412.

Rodrik, D. (2012). Why We Learn Nothing from Regressing Economic Growth on Policies. *Seoul Journal of Economics, 25*(2), 137-151.

Rondi, L., & Elston, J. A. (2009). Corporate Governance and Capital Accumulation: Firm-Level Evidence from Italy. *Scottish Journal of Political Economy, 56*(5), 634-661.

Rostow, W. W. (1960). *The stages of economic growth: A non-communist manifesto*: Cambridge University Press.

Samuelson, P. A. (1964). Theoretical notes on trade problems. *The Review of Economics and Statistics, 46*(2), 145-154.

Sarno, L., & Taylor, M. P. (2002). *The economics of exchange rates*: Cambridge University Press.

Schroder, M. (2013). Should developing countries undervalue their currencies? *Journal of Development Economics, 105*, 140-151.

Schündeln, M. (2013). Appreciating depreciation: physical capital depreciation in a developing country. *Empirical Economics, 44*(3), 1277-1290. doi: 10.1007/s00181-012-0592-2

Schwarz, G. (1978). Estimating the dimension of a model. *The annals of statistics, 6*(2), 461-464.

Shabsigh, G., & Domac, I. (1999). *Real Exchange Rate Behavior and Economic Growth-Evidence from Egypt, Jordan, Morocco, and Tunisia*: International Monetary Fund.

Shioji, E. (2001). Public capital and economic growth: a convergence approach. *Journal of Economic Growth, 6*(3), 205-227.

Solow, R. (1957). Technical change and the aggregate production function. *Readings in Macroeconomics edited by MG Mueller, Hinsdale, 111*, 323-336.

Solow, R. M. (1956). A contribution to the theory of economic growth. *The Quarterly Journal of Economics*, 65-94.

Stein, J. L. (1994). The natural real exchange rate of the US dollar and determinants of capital flows. In J. Williamson (Ed.), *Estimating equilibrium exchange rates* (pp. 133-176).

Swan, T. W. (1956). Economic growth and capital accumulation. *Economic Record, 32*(2), 334-361.

Taylor, M. P., Peel, D. A., & Sarno, L. (2001). Nonlinear Mean-Reversion in Real Exchange Rates: Toward a Solution To the Purchasing Power Parity Puzzles. *International Economic Review, 42*(4), 1015-1042.

Tervala, J. (2013). Learning by devaluating: A supply-side effect of competitive devaluation. *International Review of Economics & Finance, 27*, 275-290.

Tsionas, E. (2003). Inflation and productivity: empirical evidence from Europe. *Review of International Economics, 11*(1), 114-129.

Vieira, F. V., & MacDonald, R. (2012). A panel data investigation of real exchange rate misalignment and growth. *Estudos Econômicos (São Paulo), 42*(3), 433-456.

Willett, T. D. (1986). Exchange-rate volatility, international trade, and resource allocation: A perspective on recent research. *Journal of International Money and Finance, 5, Supplement 1*(0), S101-S112. doi: http://dx.doi.org/10.1016/0261-5606(86)90023-9

Williamson, J. (1983). *The exchange rate system* (Vol. 5): Institute for International Economics Washington, DC.

Williamson, J. (1990). What Washington Means by Policy Reform", in J. Williamson, ed., Latin American Adjustment: How Much Has Happened? Washington: Institute for International Economics.

Williamson, J. (1994). Estimates of FEERS. *Estimating equilibrium exchange rates, 177*, 245.

Williamson, J., & Mahar, M. (1998). Current account targets. In S. Wren-Lewis & R. Driver (Eds.), *Real Exchange Rates for the Year 2000*.

Wong, H. T. (2013). Real exchange rate misalignment and economic growth in Malaysia. *Journal of Economic Studies, 40*(3), 298-313.

Wooldridge, J. M. (2010). *Econometric analysis of cross section and panel data*: MIT press.

Wren-Lewis, S., & Driver, R. (1998). *Real Exchange Rates for the Year 2000* (Vol. 54): Peterson Institute Press.

Zanello, A., & Desruelle, D. (1997). A primer on the IMF's Information Notice System: IMF Working Paper.