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REAL EXCHANGE RATE MOVEMENTS
AND AGRICULTURAL TRADE

DISQUERTATION

Presented in Partial Fulfillment of the Requirements for
the Degree Doctoral of Philosophy in the Graduate
School of The Ohio State University

By
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ABSTRACT

When the international monetary system changed from a fixed to a floating system, economists generally believed that this new market based system could substantially decrease exchange rate misalignment problems between countries. However, empirical evidence in this area suggests that, during the post-Bretton Woods period, nominal exchange rates among developed countries have not followed macroeconomic fundamentals for a long period. Moreover, they have been extremely volatile in the short run. Although some economists believe that these problems have had a destructive effect on international commodity trade, there is still a considerable debate. This paper focuses on two important movements of real exchange rates (long-term variability and short-term volatility) during the post-Bretton Woods era (1974-1995), and their linkage with agriculture trade growth among 10 developed countries.

Using cross-sectional and panel data analyses, several empirical findings are obtained concerning the long-term variability issue. First, at a total trade level, there is only weak evidence that long-term real exchange rate variability has been linked with the trade growth rate. In their earlier study, De Grauwe and de Bellefroid (1986) found a significant negative relationship between these two variables. With 11 more years in
my sample, I find contradictory results. Second, in spite of this weak evidence, I find that the relationship is significant for some sectors. For instance, for large-scale industries, there is no statistically significant linkage between the two variables, while strong negative relationships between them are found for sectors producing relatively homogeneous products. Compared to other sectors, the growth of agricultural trade has been adversely affected by long-term variability in real exchange rates.

Concerning the short-term volatility issue, the estimation results are similar to those for the long-term variability issue. For instance, using a cross-sectional approach, a negative relationship between the short-term volatility measure and trade growth in the case of the total, manufacturing, and agricultural sectors is found. By examining the cross-sectional relationship between the long-term variability and short-term volatility measures, I find this similarity is due to the strong positive correlation between two measures.
Dedicated to my parents
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Special thanks are extended to my parents for their love during the years of my study in the US. I would like to express my deepest appreciation and love to my wife, Jin-Sook and my sons, Ho-Hyun and Hoon-Hyun.
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# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Abstract</th>
<th>ii</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dedication</td>
<td>iv</td>
</tr>
<tr>
<td>Acknowledgments</td>
<td>v</td>
</tr>
<tr>
<td>Vita</td>
<td>vi</td>
</tr>
<tr>
<td>List of Tables</td>
<td>ix</td>
</tr>
<tr>
<td>List of Figures</td>
<td>xi</td>
</tr>
</tbody>
</table>

Chapters:

1. Introduction                        1

2. Literature Review                   7
   2.1. Purchasing power parity         8
   2.2. Exporters' strategic behavior   13
   2.3. Foreign exchange markets       23
      2.3.1. Foreign exchange market efficiency 24
      2.3.2. Market micro-structure approach 27
   2.4. Long-term real exchange rate variability and international trade 34
   2.5. Discussion                     40

3. Theoretical Considerations         42
   3.1. Hysteresis                      43
   3.2. Effects on different industries 50
   3.3. Third moment of exchange rate distribution 54
   3.4. Time-series representation of hysteresis model 57
      3.4.1. Time-series representation 58
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.4.2. Long-term variability and short-term volatility</td>
<td>60</td>
</tr>
<tr>
<td>3.4.3. Persistency and magnitude</td>
<td>64</td>
</tr>
<tr>
<td>3.5. Discussion</td>
<td>69</td>
</tr>
<tr>
<td>4. Empirical Evidence</td>
<td>71</td>
</tr>
<tr>
<td>4.1. Variable construction and data</td>
<td>73</td>
</tr>
<tr>
<td>4.2. Cross-sectional approach</td>
<td>76</td>
</tr>
<tr>
<td>4.2.1 Simple correlations</td>
<td>78</td>
</tr>
<tr>
<td>4.2.2 Robustness</td>
<td>81</td>
</tr>
<tr>
<td>4.2.2.1 Non-EMS sub-sample</td>
<td>88</td>
</tr>
<tr>
<td>4.2.3 Alternative measure of magnitude of misalignment</td>
<td>91</td>
</tr>
<tr>
<td>4.2.3.1 Non-EMS sub-sample</td>
<td>93</td>
</tr>
<tr>
<td>4.3 Panel data approach</td>
<td>95</td>
</tr>
<tr>
<td>4.3.1 Hausman and Taylor estimator</td>
<td>96</td>
</tr>
<tr>
<td>4.3.1 Random coefficient model (RCM) approach</td>
<td>99</td>
</tr>
<tr>
<td>4.4 Discussion</td>
<td>101</td>
</tr>
<tr>
<td>5 Real Exchange Rate Volatility</td>
<td>103</td>
</tr>
<tr>
<td>5.2 A proxy variable of exchange rate uncertainty</td>
<td>107</td>
</tr>
<tr>
<td>5.3 A cross-sectional approach</td>
<td>109</td>
</tr>
<tr>
<td>5.2.1 Non-EMS sub-sample</td>
<td>112</td>
</tr>
<tr>
<td>5.4 Panel data analysis I</td>
<td>114</td>
</tr>
<tr>
<td>5.5 Panel data analysis II</td>
<td>116</td>
</tr>
<tr>
<td>5.5.1 Estimation results: within estimator</td>
<td>117</td>
</tr>
<tr>
<td>5.5.2 Estimation results: SH estimator</td>
<td>118</td>
</tr>
<tr>
<td>5.6 Cross-sectional relationship between long-term real exchange rate variability and short-term volatility</td>
<td>120</td>
</tr>
<tr>
<td>5.7 Discussion</td>
<td>124</td>
</tr>
<tr>
<td>6 Summary and Conclusion</td>
<td>126</td>
</tr>
<tr>
<td>Appendix: Panel Econometrics</td>
<td>136</td>
</tr>
<tr>
<td>A.1. General</td>
<td>137</td>
</tr>
<tr>
<td>A.2. Alternative assumption I</td>
<td>137</td>
</tr>
<tr>
<td>A.2.1. With time-invariant variable (Hausman and Taylor estimator)</td>
<td>141</td>
</tr>
<tr>
<td>A.3. Alternative assumption II: random coefficient model (RCM)</td>
<td>145</td>
</tr>
<tr>
<td>List of References</td>
<td>150</td>
</tr>
</tbody>
</table>
# LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1</td>
<td>Correlation between average export growth and real exchange rate variability (sample size = 90)</td>
<td>79</td>
</tr>
<tr>
<td>4.2</td>
<td>Average export growth and real exchange rate variability (sample size = 90)</td>
<td>84</td>
</tr>
<tr>
<td>4.3</td>
<td>Sample average of the variables</td>
<td>88</td>
</tr>
<tr>
<td>4.4</td>
<td>Average export growth and real exchange rate variability: non-EMS case (sample size = 70)</td>
<td>89</td>
</tr>
<tr>
<td>4.5</td>
<td>Estimation results with alternative measures (sample size = 90)</td>
<td>93</td>
</tr>
<tr>
<td>4.6</td>
<td>Estimation results with alternative measures</td>
<td>94</td>
</tr>
<tr>
<td>4.7</td>
<td>Export growth and real exchange rate variability (Hausman and Taylor estimator, sample size = 1980)</td>
<td>97</td>
</tr>
<tr>
<td>4.8</td>
<td>Export growth and real exchange rate variability (The modified Swamy-Hsaio estimator, sample size = 1980)</td>
<td>100</td>
</tr>
<tr>
<td>5.1</td>
<td>Relationship between average export growth and average exchange rate uncertainty (sample size = 90)</td>
<td>110</td>
</tr>
<tr>
<td>5.2</td>
<td>Relationship between average export growth and average exchange rate uncertainty: non-EMS case (sample size = 70)</td>
<td>113</td>
</tr>
<tr>
<td>5.3</td>
<td>Relationship between export growth and exchange rate uncertainty (time fixed effect model, sample size = 1980)</td>
<td>115</td>
</tr>
<tr>
<td>5.4</td>
<td>Relationship between export growth and exchange rate uncertainty (within estimator, sample size = 1980)</td>
<td>118</td>
</tr>
</tbody>
</table>
5.5 Relationship between export growth and exchange rate uncertainty (SH estimator, sample size = 1980) ............................................................... 119

5.6 Cross-sectional correlation between two measures (sample size = 90) .... 121
LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1 Hysteresis</td>
<td>47</td>
</tr>
<tr>
<td>3.2 Effects of exchange rate movement on different industries</td>
<td>52</td>
</tr>
<tr>
<td>3.3 Effects of skewness of distribution</td>
<td>55</td>
</tr>
<tr>
<td>3.4 Time-series representation of the hysteresis model</td>
<td>58</td>
</tr>
<tr>
<td>3.5 Short-term volatility vs. long-term variability</td>
<td>61</td>
</tr>
<tr>
<td>3.6 DM/U.S.$ nominal and real exchange rates, relative prices</td>
<td>63</td>
</tr>
<tr>
<td>3.7 Some real exchange rate movements</td>
<td>65</td>
</tr>
<tr>
<td>3.8 Empirical probability densities of some real exchange rates</td>
<td>67</td>
</tr>
</tbody>
</table>
CHAPTER 1

INTRODUCTION

In the late 1960s and early 1970s, the majority view among economists was that a market based floating exchange rate system could be the proper way to avoid exchange rate misalignment. Considering the fact that, under the fixed exchange rate system, the main source of misalignment was government effort to maintain nominal exchange rates, which were no longer justified by underlying economic fundamentals, this belief seems to be natural. This optimistic belief about the floating exchange rate system also strongly depended on the persuasion of Friedman (1953). He argued that, under the market-based system, rational speculators in the foreign exchange market would stabilize rather than destabilize exchange rates in the long run. Anyone who increased the magnitude of exchange rate misalignment could only do so by buying high and selling low, irrational currency traders should be going out of the market due to rational

---

1 Misalignment, in general, refers to the departure of nominal exchange rates from long-run equilibrium level or market fundamentals such as relative prices and interest rate differentials between countries.

2 Unreasonable exchange rate management policies are still one of the important sources of misalignment for some of the developing countries, which have pegged their nominal exchange rate to major currencies such as US dollar. Tweeten (1989a) explains the potential process of how these misguided exchange rate management policies can cause serious problems in these economies.
speculators\(^3\). Consequently, rational speculators in the foreign exchange market more efficiently find the relative value of two currencies, which could solve misalignment problems substantially in the long run (Frankel, 1996).

However, unlike this ideal belief, the new international monetary system has also produced new problems. Casual empirical observation suggests that: under the floating exchange rate system, the movement of nominal exchange rates between developed countries has not reflected much information relating to movement of economic fundamentals between countries, especially, in the short- and medium-run. Consequently, the deviation of nominal exchange rates from their macroeconomic fundamentals has been \textit{substantial} and \textit{persistent} so that the misalignment problem seems not to be substantially mitigated under the new system (Dornbusch, 1987b; Rogoff, 1996). Simply, the demonstration that the floating system is \textit{viable} has not been matched by a consensus that it is \textit{desirable} (Williamson, 1985).

In connection with international commodity trade, two different types of misalignment problem have been important in the relevant literature. The first one is their \textit{persistency}. For example, if under- (or over-) valuation of a currency tends to continue for several years in a row, it might affect international commodity trade flows. Studies related to the law of one price (LOP) and purchasing power parity (PPP) have concentrated on the persistency of misalignment. Also, recent empirical evidence shows that PPP is a long-run equilibrium condition of nominal exchange rates, however,\footnote{I will review the empirical evidence and theoretical considerations related to Friedman’s hypothesis in chapter 2.}
the misalignment among developed countries has been quite persistent during the post-Bretton Woods era (Rogoff, 1996).°

The second type, considered in the present paper, is the **magnitude** of misalignment (or long-term real exchange rate variability). According to the *hysteresis* model of Baldwin (1988) and Baldwin and Krugman (1989), the magnitude of misalignment is an important factor affecting international commodity trade. Under the assumption of imperfect competition, theory suggests the possibility that cyclical misalignment can cause cyclical structural changes in international commodity markets in the long run if *its magnitude is large*. Within a moderate range of deviation, however, theory implies that the effect should not be so easily detectable because international commodity traders can strategically adjust their behavior. Moreover, their model also suggests a possibility that extreme over- (under-) valuation of a currency could result in a significant decrease (increase) in exports that is not matched by subsequent small favorable (unfavorable) exchange rate shocks due to the hysteresis effect of exchange rates.

On the other hand, relevant theory and empirical evidence in this area suggests that exchange rate movements possibly have different effects on different exporting sectors because each industry has different specific characteristics. Different degrees of initial investment costs (Baldwin, 1988), substitutability of products (Dornbusch, 1987a), and durability of products (Froot and Klemperer, 1989), are all important determinants of

---

° Based on theory and recent empirical evidence of PPP, I will use the term ‘movement of misalignment’ and ‘movement of real exchange rate’; and ‘magnitude of misalignment’ and ‘long-term real exchange rate variability’ interchangeably. More detailed discussion about this terminology will be presented in the next chapter.
the reaction of commodity traders’ responses to exchange rate shocks. In general, agricultural goods have their specific characteristics compared to other manufactured goods. For example, they are tradable, almost perfectly substitutable, non-durable, and the initial investment costs of entering the foreign market are not an important factor in affecting traders’ decisions. Due to these specific characteristics, it is expected that the effect of exchange rate misalignment on agricultural trade could be different from other large-scale manufacturing industries a priori.

The hysteresis model suggests the possible real impact of exchange rate fluctuation on international trade flows on theoretical grounds. However, the question of whether ex-post realization of real exchange rate variation under the floating system has been large enough to cause a negative real impact on international trade flows is ultimately an empirical one. In fact, there is no consensus among economists about this question. For instance, some economists argue that, due to the potential failure of foreign exchange markets, the pure floating system has produced cyclical misalignment problems, which are much larger than that of any naturally acceptable range (i.e., Williamson, 1985, 1987; Krugman 1989; McKinnon, 1996). Consequently, they suggest different proposals about the international monetary system. However, some economists, following Friedman (1953), seem to believe that foreign exchange markets cannot be so inefficient. Therefore, misalignment, under the pure floating system, has not been large enough to cause a real impact on long run trade flows. Consequently, long run exchange rate neutrality holds under the floating system.

---

5 More detailed discussion about the different proposals about international monetary reform is summarized in Frankel (1996).
In fact, this debate is strongly related to the substantial part of misalignment under the floating system, and the relevant issue is clearly an empirical one. However, studies examining this issue are rare, and the possibility of different sectoral effects of exchange rate movements has long been ignored in the relevant literature. Therefore, the overall aim of the present paper is to address some of the unsolved empirical questions related to exchange rate movement in the post-Bretton Woods era. With bilateral trade data covering ten developed countries over the period of 1974-1995, the following issues will be addressed empirically.

First, using cross-section and panel data analyses, whether the ex-post realization of real exchange rate variability during the post-Bretton Woods period has been large enough to affect long run agricultural trade growth rate will be examined. Based on the theory of long run PPP, long-term real exchange rate variability between countries is considered as a proxy variable of the overall magnitude of misalignment that countries have faced during the sample period. Furthermore, by examining the linkage between variables for three additional industry sectors, the possible different sectoral effect of long-term real exchange rate variability will be examined. Finally, by including the third moment of the real exchange rate distribution into the empirical model, the validity of Baldwin and Krugman’s hypothesis will also be examined.

Second, the question of whether increased short-term exchange rate volatility under the floating system has caused a real negative impact on agricultural trade flows will also be examined using a cross-sectional analysis as followed by Rose (2000).

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6 In chapter 4, I will explain why the third moment of the real exchange rate distribution is important for testing Baldwin and Krugman’s hypothesis empirically.
After that, by employing panel data analyses, the time-series linkage between variables will also be examined. With these comparisons, we might have an answer as to why short-term exchange rate volatility is still an important issue for agriculture trade, although time-series evidence is weak. Finally, in considering the cross-sectional linkage between long-term variability and short-term volatility of real exchange rates, a brief discussion will be presented as to why these two seemingly different issues should not be treated separately.

The paper is organized as follows: In chapter 2, I will review the relevant literature. In chapter 3, a theoretical consideration that examines the possibility of different sectoral effects of exchange rate movements will be presented. In chapter 4, data construction, econometric specification, and results will be presented, which might show why exchange rate movement is more important to trade in the agricultural sector compared to other export sectors. In chapter 5, by including a short-term volatility measure into the empirical model, I will examine whether increased short-term exchange rate volatility has also caused any real impact on agricultural trade growth. In addition, a potential relationship between the two issues will be examined. In chapter 6, a summary and conclusion is provided.
CHAPTER 2

LITERATURE REVIEW

In this chapter, I will review the relevant literature focusing on four different subjects. The first subject concerns purchasing power parity (PPP), which is considered one of the important long-run equilibrium conditions of nominal exchange rates between countries. Due to the main objective of the study being related to movements of real exchange rates, understanding a basic concept of PPP and relevant empirical findings is important. The second subject is literature concerning the strategic behavior of international commodity traders. Under assumptions of imperfect competition and exogenous movements of exchange rates, how commodity traders have adjusted their behavior in response to given under- or over-valuation of their currency is the main subject in this literature. Reviewing this topic is helpful in understanding why we expect that a given exchange rate movement can affect different industry sectors differently. Third, the relevant theory and empirical evidence relating to foreign exchange market efficiency will be reviewed. Moreover, the major empirical findings of the recently developed ‘market microstructure’ approach, which directly investigates
the behavior of the foreign exchange market participants using survey data, will also be briefly reviewed. Through an understanding of an important source of exchange rate misalignment under the floating system, we can more easily understand the underlying reason why some economists have worried about the pure floating system. Finally, a traditional opinion about the cost of cyclical misalignment under the floating system, which is based on political economy, will be discussed.

2.1. Purchasing Power Parity

Exchange rate misalignment, in general, can be defined as the departure of the nominal exchange rate from its long-run equilibrium level. Measuring misalignment is actually difficult and inherently imprecise, as it requires estimation of what is termed the fundamental equilibrium exchange rate. Typically in the literature, it is assumed that purchasing power parity (PPP) is one of the long-run equilibrium conditions of nominal exchange rates.

Essentially, based on Cassel's (1922) argument, PPP should hold because exchange rates equalize relative price levels in different countries. The standard expression for absolute PPP is:

\[ s_t = p_t - p_t^* \]

where \( s_t \) is the home currency price of a foreign currency, \( p_t \) is the domestic-currency price of a particular good(s), \( p_t^* \) is the foreign currency price of the good(s), and lower case letters denote logarithmic values. The implication of (2.1) is that trade in goods will result in identical prices across countries. Allowing for factors such as transport
costs, PPP in its \textit{relative} form implies that a stable price differential should exist for the same good(s) selling in different countries, the implication being that real exchange rates between countries should be equal to a constant in the long run, and, consequently, there is no persistent misalignment of exchange rates from relative PPP, \textit{i.e.}, the real exchange rate should be mean-reverting (MacDonald, 1999).

There has actually been a long debate in the literature as to whether such deviation exists. Traditional macroeconomic theory does not support the existence of a \textit{substantial} and \textit{persistent} deviation of nominal exchange rates from market fundamentals. Empirical evidence published mostly in the 1980s, however, was not very favorable to this view. Researchers essentially tested for whether the log of the real exchange rate, $r_t$, is stationary:

\begin{equation}
\label{eq:2.2}
r_t = s_t - p_t + p^*,
\end{equation}

Several studies could not reject the hypothesis of a random walk of real exchange rates under the flexible exchange rate regime (Adler and Lehman, 1983; Meese and Rogoff, 1983). As a result, it led to the belief that PPP was of little use empirically, and, real exchange rate movements were highly substantial and persistent (Dornbusch, 1987b).

In more recent research, the focus has been on the use of co-integration methods applied to the following equation:

\begin{equation}
\label{eq:2.3}
s_t = \beta + \alpha_0 p_t + \alpha_t p^* + \varphi_t,
\end{equation}

If $s_t$, $p_t$, $p^*$ are integrated of order one, I(1), then a weak form of PPP exists if the residual term from estimation of (2.3) is stationary, I(0), and a stronger form of PPP
exists if homogeneity is satisfied \(i.e., \alpha_0 = 1, \text{ and } \alpha_1 = -1\). Using this type of approach, several early studies found no evidence of significant mean reversion of exchange rates toward PPP (Mark, 1990; Fisher and Park, 1991).

A number of authors have argued that the data period for the recent float alone may simply be too short to provide any reasonable degree of test power in normal statistical tests for stationarity of real exchange rates (Frankel, 1990; Lothian and Taylor, 1997). Researchers have sought to remedy this with two different approaches. One group has examined long-term, and, hence, largely pre-float data for the major industrial countries. For example, Lothian and Taylor (1996) utilize sterling-dollar and sterling-franc exchange rate data spanning the two centuries ending in 1990, and find strong evidence in favor of mean-reversion in the real exchange rate. Another group has examined the issue using multi-country panel data. Flood and Taylor (1996), for example, analyze a panel of annual data for 21 industrialized countries over the floating rate period and find strong support for mean reversion towards long-run purchasing power parity by regressing 5, 10, and 20 year average exchange rate movements on average inflation differentials with the US. Frankel and Rose (1996) analyze a very large panel of annual data on 150 countries in the post World War II period and find evidence of mean reversion. Taylor and Sarno (1998) examine the issue using a monthly data of panel of G7 countries. With a panel unit root test, they also can reject the null of nonstationarity of real exchange rates\(^1\). As a whole, researchers have now

---

\(^1\) Recently, there has been a lot of empirical evidence about mean reverting behavior of real exchange rates, for example, MacDonald (1996); Lothian (1997); Papell (1998); all reach the similar conclusion of mean reversion of real exchange rates using multi-country panel data.
begun to reject the real exchange rate random-walk hypothesis. They find that real exchange rates revert to equilibrium values over the long run, and correspondingly, that nominal exchange rates and relative price levels converge, thus reviving the view of PPP as a long-run equilibrium condition. However, as Rogoff (1996) notes, consensus estimates suggest that the speed of convergence to PPP is very slow; deviations appear to damp out at a rate of roughly 15 percent per year\(^2\). The slow adjustment speed implies the existence of a substantial non-stationary component in real exchange rates, although the recent majority of empirical studies rejects the non-stationarity of real exchange rates among developed countries (Engel, 2000)\(^3\).

Two important points should be discussed here. First, can we treat PPP as a long run equilibrium condition of nominal exchange rates between countries? Many economists such as McKinnon (1988) have argued in favor of the reasonability of PPP as an equilibrium condition in the long run. However, Krugman (1989), Dornbusch (1988), and Pick and Vollrath (1994) have argued that PPP is not a proper indicator of the equilibrium condition of nominal exchange rates even in the long run. Simply, they believe that equilibrium exchange rates need to change, even if inflation rates between

\(^2\) Due to this extremely slow adjustment of nominal exchange rates, we need to collect data over a long time period rather than high frequency time-series data for an empirical study. This is also an important reason why a cross-sectional approach is preferred to a time-series approach. With shorter-time series data with high frequency, it might be difficult to obtain a proxy variable of the magnitude of exchange rate misalignment between currencies.

\(^3\) These slow mean reversion results are not limited to the case of PPP. For instance, Engel and Hamilton (1990), in considering movement of the US dollar during the period of 1973-1988, found that dollar movements during the 1980s were not explained by interest differentials between countries while rejecting the null of an exchange rate random walk in favor of long swings. Mark (1995), in considering US dollar movements over the period 1973–1991, found evidence that quarter to quarter exchange rate movements may be unpredictable, while systematic movements of exchange rates related to the fundamentals such as relative money stock and real income become much more apparent over a long-horizon (16 quarter). Consequently, it is clear that long deviations of nominal exchange rates are not limited to the case of PPP.
countries are not changed, because there are changes in real factors such as a change of underlying preferences of consumers about foreign and domestic products and changes of relative productivity between countries. In spite of that, I will use PPP as a long run equilibrium condition in the present paper. The reason is not because I believe PPP is an exact long run equilibrium condition but I believe that exact measurement of the long run equilibrium condition of nominal exchange rates is impossible⁴. Moreover, the terms 'movement of misalignment' and 'movement of real exchange rates' and 'magnitude of misalignment' and 'long-term real exchange rate variability' are used interchangeably in this study based on a strict version of PPP. The underlying rationale is as follows: if a strict version of long-run PPP holds, as shown in (2.3), the nominal exchange rate is given as, \( s_t = \beta + \alpha_0 p_t + \alpha_1 p^*_t + \varphi_t, \) \( \alpha_0 = 1, \) and \( \alpha_1 = -1, \) and the underlying innovation \( \varphi_t \) should be a stationary process, which has mean zero and finite long-run variance, \( \sigma^2_\varphi. \) The time-series movement of the estimated residuals, \( \hat{\varphi}_t, \) can be thought of as the time-series movement of misalignment, and the estimated \( \hat{\sigma}^2_\varphi \) is the magnitude of misalignment over a long period. Furthermore, under the assumption of long-run PPP, we can also express the equation as, \( s_t - p_t + p^*_t = \beta + \varphi_t. \) The left-hand side is simply the log of the real exchange rate, \( r_t, \) so that it can be also expressed as, \( r_t = \beta + \varphi_t. \) It is important to note that \( E(r_t) = \beta, \) and \( \text{VAR}(r_t) = \text{VAR}(\varphi_t) = \sigma^2_\varphi. \) Therefore, as the estimated variance (or standard

⁴ The difficulty of finding equilibrium nominal exchange rates between countries is because there are so many unobservable factors considered as fundamentals of nominal exchange rates (i.e., changing preferences and relative productivity).
deviation) of \( r_i \) is equal to the estimated variance (or standard deviation) of \( \varphi_i \), it is used as a proxy for the magnitude of exchange rate misalignment.

Second, although recent empirical findings of PPP are important in connection with the validity of macroeconomic theory, stationarity of real exchange rates does not give us any answer about the question whether the misalignment problem under the floating exchange rate system has been large enough to cause any real impact on international commodity trade. Tests for stationarity of real exchange rates can only answer the 'persistent' part of the story of exchange rate misalignment. However, the 'substantial' part of misalignment under the floating exchange rate system may be a more important question in connection with theory such as the hysteresis model suggested by Baldwin (1987) and Baldwin and Krugman (1988). Simply, a persistent but small amount of misalignment might not cause real instability of international commodity flows, but a one-time, large deviation can.

2.2. Exporters' Strategic Behavior

Under the assumption of the existence of substantial misalignment between currencies, the question of how rational commodity traders have adjusted their behavior in response to given\(^5\) exchange rate movements is one of the most popular subjects in international economics. In fact, many theoretical papers based on industrial

\(^5\) As Dornbusch (1988) indicates, most microstructure models in this area assume exogenous (or given) movements of exchange rates. However, because, under the floating system, exchange rates are an endogenous variable, this assumption is highly restrictive. In the present paper, the theoretical and empirical analyses are also based on the assumption of exogenous exchange rates, and this is an important limitation of the present study.
organization theorems have tried to answer this question, and there is also some empirical evidence supporting the theory.

The first finding from the relevant literature is that rational exporters set their export prices strategically. Many empirical studies have found evidence that exporters strategically decide their export price given exchange rate movements. For instance, it has been generally observed that, when there has been substantial over-valuation of an exporter's currency, exporters do not fully increase their export price denominated in the destination country's currency. In contrast, if there has been a substantial under-valuation, exporters also do not fully decrease their export price. This is called "incomplete or partial pass-through of exchange rates" or "pricing to market" (PTM) behavior of exporting firms in the relevant literature.

Based on the movement in four-digit industry U.S. import prices relative to a trade weighted average of foreign production costs, Mann (1986) concluded that foreign profit margins are adjusted to mitigate the impact of exchange-rate changes on dollar prices of U.S. imports. Giovannini (1988) documents large deviations from the law of one price between export and domestic prices of some narrowly defined Japanese manufactured goods: ball bearings, screws, and nuts and bolts. Knetter (1989) shows strong evidence of partial passing-through of exchange rate changes on German exports to a variety of destinations using seven-digit industries. Knetter (1993) extended his study using US, UK, German, and Japanese industry level data and found strong evidence of partial passing through in the UK, German, and Japanese data.
Basically, two theoretical models explaining the motivations of exporters are very popular in this area. Baldwin (1988) suggested a supply side story. The story is simply as follows. It is assumed that there is an exporting firm which is already operating in a foreign market, and it is also assumed that the firm has spent substantial initial sunk costs (i.e., developing a dealer system), to enter the market last period. Further, assume that there is substantial over-valuation of the exporter’s currency in this period. The model suggests that, if the over-valuation were within some moderate range, the exporter would not get out of the destination market. This is simply the best policy of the exporting firm if they believe that exit from and reentry to the market is more expensive due to irreversible initial investment than staying in the market and waiting for future exchange rate movements. Moreover, it is logically true that, if the foreign market were perfectly competitive, the export firm would sell its product at the destination market-clearing price. In this case, we would observe a perfect disconnection between nominal exchange rate movements and export prices denominated in the destination country’s currency. On the other hand, if the destination market were either imperfectly competitive or export products were imperfect substitutes, then the firm would strategically decide its export price under the given destination market conditions. In this case, we would observe a partial passing through of the exchange rate.

Froot and Klemperer (1989) emphasize the exporting firm’s motivation to keep its market share in the destination country. Why is market share so important? First, consumers in an importing country may face substantial costs of switching between
brands of product even if the brands are functionally identical. For example, consumers who have learned to use one type of videocassette recorder find it costly to learn a new one with identical capabilities. Second, a consumer may be unwilling to switch from a brand that they have tried and liked to an untested rival brand. Indeed, consumers incur search costs even in finding out about the existence or price of a competing product. Due to the fact that the exporter knows this consumer behavior, they would not change product price denominated in the destination market currency even when there is a substantial overvaluation of exporters’ currency. Simply, Froot and Klemperer show the possibility that the cost of losing market share in a destination country is greater than the cost of staying in the market even when there is a substantial over-valuation of the exporter’s currency.

There are many other factors that affect the price decision of exporters noted in the literature. For instance, Dornbusch (1987a) shows that, in a Cournot model, the price adjustment of exporting firms should depend on at least three factors in general: the degree of market concentration, the relative market shares of domestic and foreign firms, and, most importantly, substitution between domestic and foreign variants of a product. Knetter (1988,1993) emphasizes the mark up of the exporting firm and the demand elasticity of the product in the destination market.

However, an interesting question about previous theoretical work is why do exporters adjust their export price but not quantity? Goldberg and Knetter (1999) recently emphasize that quantity adjustment mechanisms associated with price decisions should be important in order to draw more complete inferences of strategic
behavior. In their theoretical model, even more factors affect an export firm’s decisions such as movement of exchange rates between competitors and the destination country, and the elasticity of the competitors’ supply.

As a whole, the theory has implicitly emphasized the industrial level effect of nominal exchange rate misalignment. In the case of durable and non-homogeneous goods, exporters might have much more possibility of price discrimination between the home and destination market under the assumption of some degree of imperfect competition. However, in the case of non-durable and homogeneous goods, exporters might not have any strong motive for strategic price setting. Empirical evidence supports the asymmetric effect hypothesis. For example, many empirical studies have found evidence for strategic behavior of an exporting firm concentrated on manufacturing goods. However, Pick and Park (1991) did not find any strategic price decision behavior for US exporters of soybeans and corn, although the US has dominant power in the world agricultural market. Yang (1997) also found some evidence that pass-through is incomplete and varies across industries.

Another line of literature has concentrated on the entry and exit decision of exporting firms in response to a given exchange rate movement. Therefore, it is related to the long-run decision problem of traders. In fact, this story is strongly connected with the ‘partial passing through’ literature because it simply concentrates on the case that the deviation is out of some range. According to Baldwin (1988), and Baldwin and Krugman (1989), if firm entry cost to a new market is sunk and big enough, there are some ranges of inaction of an exporting firm’s entry and exit decision in response to
exchange rate movements. For example, if Toyota is already in the US market and invests a lot of initial cost (i.e., constructs a dealership system etc.), it is the best strategy to stay in the US market even when there is a substantial over-valuation of the Yen. Furthermore, if a large unexpected nominal exchange rate shock were to occur, in other words, if there is an unexpected large misalignment problem between currencies, it can cause a permanent change in market structure. For instance, if a shock like the over-valuation of the US dollar in the 1980s were to occur, a lot of foreign firms entered the US market so that the US’s market structure changed. However, even when the initial misalignment problem was resolved, (i.e., the US dollar aligned properly in this example), foreign firms did not get out of the US market due to irreversible initial sunk cost. This is the so-called ‘hysteresis’ effect of exchange rate changes. Although the existence of nominal shocks that can cause structural changes between countries even at the aggregate level is still a controversial subject, it is now generally accepted that there is some range of inertia of exporters’ entry and exit decisions in response to exchange rate movements. Another influential model was suggested by Dixit (1989). He shows that greater uncertainty via more volatile short-term exchange rates makes trade flows less responsive to changes in these variables, in other words, the inaction range becomes larger with higher short-term volatility. However, as mentioned in Rogers and Jenkins (1995), even in this case, initial entry costs to the market must be different from industry to industry. Therefore, for industrial level behavior, say, the range of inaction might be different from industry to industry. In an extreme case, if an industry does not need to enter a foreign market, the theorem might not even be applicable. In section 3, I will explicitly show the possibility of asymmetric effects of nominal exchange rate
What economic intuition can we get from this existing literature? In general, the relevant theoretical literature gives us three important economic intuitions. First, strategic behavior of traders during the floating exchange rate regime is one of the most popular explanations of deviations of nominal exchange rates from the law of one price (LOP) and PPP. Even when nominal exchange rates deviate initially from the LOP and PPP, exporters do not sharply change their export prices denominated in destination country currencies. As a result, the relative price differential is much more stable compared to nominal exchange rate movements so that the nominal exchange rate misalignment problem is persistent. Second, even if there is a substantial deviation of nominal exchange rates from market fundamentals, international traders strategically respond to this deviation so that international trade flows do not fluctuate as much as the nominal exchange rate variation. In other words, theory implies that nominal exchange rate shocks might not have directly translated into changes in the volume of international trade. Under the assumption of existence of imperfect competition and substantial mark-ups of exporting firms, firms have adjusted the available mark-up given nominal exchange rate movements rather than generate a sharp increase or decrease in their export volume.

However, the theory also implies that, in the long run, the variation of trade flows due to real exchange rate variation might be different from industry to industry because different industrial sectors have specific characteristics. If we think the exchange rate shock is an aggregate level shock, there is no reason to believe that all industries react

 movements on different industry sectors based on a hysteresis model originally proposed by Baldwin and Krugman (1989).
in the same direction and magnitude in response to this aggregate level shock. In the extreme case, for an exporting firm which exports a perfectly substitutable non-durable good, and does not even need to enter a foreign market selling its product, the best strategy of the firm given substantial overvaluation of their currency might be simply to temporarily shut down their exports. The best strategy is simply no strategy. Therefore, long-term real exchange rate variability might have caused more variation of trade flows in this sector.

Finally, it is important to note here that, in the long run, like the present study, the theory might not give us any directional effect of real exchange rate variability on export growth if we believe exchange rate movements are symmetric, and firms are risk neutral. For instance, according to recent empirical evidence, real exchange rates have cyclically deviated from their mean value. In other words, if one currency starts to be overvalued, this overvaluation sustains for several years until it comes back to its equilibrium value. This cyclical under or overvaluation has repeatedly occurred in the floating exchange regime. Therefore, exporters might have faced over-valuation of their currency over some period while they also have experienced under-valuation over other periods. During the period of over-valuation of their currency, they might have experienced some struggle to export. However, they have adjusted their behavior using available tools for the reasons we previously mentioned. In contrast, they have enjoyed additional profit during the period of under-valuation of their currency. Even in the Dixit (1989) model, short-term volatility deters new foreign entry in the domestic market but it simultaneously deters exit of foreign firms that are already in the domestic
market. Therefore, over a relatively short time period (i.e., four of five years), we could easily observe the effects of misalignment, but over a long period, it might be difficult to justify a sign of the relationship between long-term real exchange rate variability and international trade on theoretical grounds.

In fact, some economists (i.e., Cheung et al., 1999) argue that the feature of imperfect competition is the main source of exchange rate misalignment. The argument is that, given a deviation in nominal exchange rates, commodity traders stick their exporting prices in the destination market price denominated by the destination currency. As a result of this, deviation of nominal exchange rates from PPP can be persistent, so that we can observe slow mean reverting behavior of real exchange rates. We can accept that the strategic price setting behavior of exporters (under the assumption of imperfect competition in world commodity markets) is an important source of the persistent misalignment problem. However, if someone argues that this is the main source of the misalignment problem, I believe that the argument ignores an important part of the story of real exchange rate movements during the post-Bretton Woods era. There are at least two reasons why one can not easily accept this argument.

First, there is empirical evidence that shows there are regime-specific differences in exchange rate movements. Mussa (1986, 1990), and Hasan and Wallace (1996) have demonstrated that nominal and real exchange rate volatility have moved closely together, both being substantially lower during the fixed exchange rate regime than the floating regime. Flood and Rose (1999) found that nominal exchange rate volatility during the floating regime has been between three and nine times higher than during the
fixed exchange regime. However, macroeconomic variables such as money, output, and prices have approximately comparable volatility during the fixed and flexible exchange rate regimes. Rose (2000) also found the width of the officially announced band such as the European Monetary System (EMS) has a significant effect on exchange rate volatility, even in the absence of change in the variability of macroeconomic fundamentals. The empirical evidence, as a whole, shows us that the international monetary system is an important factor in determining movements of exchange rates. Under the logic of the imperfect competition argument, should we interpret it as evidence that European countries have a more competitive commodity market structure? How can the imperfect competition argument explain the radical difference between real exchange rate movements after changing regimes as in the case of Ireland? Suddenly, did a structural change in commodity markets occur due to the change in monetary reform? Krugman (1989) argues imperfect competition (or segmented world commodity markets) is one of the important reasons for explaining exchange rate movements during the post-Bretton Woods era. However, Krugman also argues that this is not the whole story. He notes: “Exchange-rate instability has resulted not only from reasonable market responses to changes in policies and underlying conditions but also from failures in the international financial markets” (p 77). Simply,

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7 Although these empirical findings are related to short-term volatility, I find that cross-country differences of short-term volatility and long-term variability (magnitude of misalignment) are strongly correlated with each other. In chapter 5, I present more detailed empirical results related to this issue.

8 It is well known that, before Ireland joined the EMS, its real exchange rate was more closely related with that of the UK than with that of Germany; after Ireland joined, it became more correlated with Germany than with the UK.
without a given initial deviation of the exchange rate, there is no reason for commodity traders to adjust their behavior.

Second, some economists seem to believe that international commodity traders have determined the nominal exchange rate during the floating system. However, in reality, internationally mobile capital should be the most important factor in determining nominal exchange rates. For instance, daily turnover in the foreign exchange market was $880 billion as of April 1992, while daily US GNP was $22 billion; daily worldwide exports amounted to $13 billion (Frankel and Rose, 1995). Because the transaction volume in foreign exchange markets is a hundred times greater than the volume of commodity trade flows, it is difficult to believe that these are servicing international commodity trade. In addition, under traditional macroeconomic models, it is difficult to rationalize this tremendous increase in gross volume of trading on foreign exchange markets. Therefore, it is desirable to understand what has happened in the foreign exchange market during the floating regime. Although this topic is not directly related to the main theoretical and empirical findings of the present study, I believe that understanding this topic is important in understanding the main point of recent debates about the movement of exchange rates under the floating system, and in deriving policy implications from the empirical results.

2.3. Foreign Exchange Markets

Understanding foreign exchange markets is important because available macroeconomic models have not appropriately explained exchange rate movements
under the floating system (Dornbusch, 1987b; MacDonald and Taylor, 1992; Frankel and Rose, 1995). Tremendous transaction volumes in foreign exchange markets and different behavior of exchange rates between the fixed and floating exchange regimes also trigger direct investigation into foreign exchange markets. In this subsection, I will briefly review empirical findings about foreign exchange market efficiency. In addition, empirical findings of the market microstructure approach, which more directly examines foreign exchange market participants with survey data, will also be reviewed.

2.3.1. Foreign Exchange Market Efficiency

Under the efficient market (or fully revealing rational expectation) hypothesis, market prices reflect all the relevant private information available to market participants. As a result, traders ignore their own private information and make an identical decisions. Therefore, it should be impossible for traders to earn excess returns using their private information if a speculative market is fully efficient.

To empirically test whether foreign exchange markets are fully efficient, economists have conducted regression analysis of spot and forward exchange rates. Under the rational expectations and identical economic agent assumption, the following relationship should hold

\[ \Delta s_{t+k} = \Delta s_{t+k}^e + \eta_{t+k}, \quad \Delta s_{t-k}^e = E(\Delta s_{t+k} | I_t), \]

9 This review is based on MacDonald and Taylor (1992) and Taylor (1995).

10 Grossman and Stiglitz (1980) show the impossibility of informationally efficient speculative markets. If gathering private information is costly, market price can not reveal all the information of market participants because nobody wants to gather his/her private information with cost. Their theorem, in fact, implies a possibility of intrinsic informational inefficiency in foreign exchange markets.
where $\Delta s_{t+k} = s_{t+k} - s_t$, $\Delta s_{t+k}^e = s_{t+k}^e - s_t$. $s_t$ is the logarithm of the spot exchange rate, which is assumed to be the home currency price of a foreign currency. $s_{t+k}^e$ denotes the expected exchange rate at time $t$. $E$ is the mathematical conditional expectation operator. $I_t$ is the information set available at time $t$, which contains all the available economic models and data and so on. $\eta_{t+k}$ is a random forecasting error, orthogonal to the information set (i.e., $E(\eta_{t+k} | I_t) = 0$).

Under the assumption that economic agents are risk neutral and fully rational, we expect that the forward rate for maturity $k$ periods ahead should be equal to the market's expectations of the spot rate at time $t+k$:

$$f_t^k = s_{t+k}^e$$

(2.5)

where $f_t^k$ is the logarithm of the forward rate for maturity $k$ period ahead. By substituting equation (2.5) into equation (2.4), we can obtain a basic empirical model,

$$\Delta s_{t+k} = \alpha + \beta f_t^k + \eta_{t+k},$$

(2.6)

where $f_t^k = f_t^k - s_t$, which denotes the forward premium. If agents are risk neutral and fully rational, we would expect $\alpha = 0$, $\beta = 1$. Empirical evidence on equation (2.6) is not favorable to the efficient market hypothesis under risk neutral agents. For example, Bilson (1981) estimates equation (2.6) using monthly data for the period of July 1974 to January 1980, with a sample of spot and 1-month forward US dollar prices of the nine major currencies. He strongly rejects the null hypothesis that the forward premium is an unbiased forecast of the future spot rate. For instance, using a pooled cross-section...
time-series regression under the restriction of the same slope coefficients across the cross-section, the estimated slope coefficient was \(-0.822\). Fama (1984) also examines a similar data set, and, using a seemingly unrelated regression (SUR), he also finds negative estimates of \(\beta\) in all nine currencies. Gregory and McCurdy (1984) investigate 1-month Canada/United States forward exchange rates for the period of 1973 to 1981. They also found a significant negative point estimate of \(\beta\), although the test relations vary from period to period. Overall, regression based estimation results suggest a significantly negative point estimate of \(\beta\). For instance, the average coefficient across some 75 published estimates during the 1980s is \(-0.88\) (Froot and Thaler, 1990). More recently, Wu and Zhang (1997) adopt a distribution-free, non-parametric approach (i.e., Fisher’s sign test and Wilcoxon’s signed rank test) to examine the efficient market hypothesis. They also find overwhelming evidence against the unbiasedness hypothesis for the forward US dollar prices of the five major currencies.

This negative point estimate of \(\beta\) is usually explained in one of two ways. Some authors argue that this estimated coefficient is evidence of a time-varying risk premium on foreign exchange. For instance, Fama (1984) decomposes the forward premium \((fp_t^k = f_t^k - s_t)\) into the expected rate of depreciation \((E(s_{t+k} - s_t | I_t))\) and a risk premium, \((\lambda_t = f_t^k - E(s_{t+k} | I_t))\). Under the assumption of rational expectations, he further shows that the regression slope coefficient \(\beta\) can be negative if the risk premium is negatively correlated with the expected currency depreciation.
Alternatively, Froot and Frankel (1989) do not assume rational expectations *a priori*, and decompose the slope coefficient in a different way. They demonstrate that the negative value of the regression slope coefficient is caused by systematic expectation error rather than a risk premium. Consequently, there is a consensus that the forward price is a biased indicator of the future spot exchange rate. However, there is still remaining debate about interpretation of the empirical findings.

Overall, the empirical literature shows us that, under the floating exchange rate system, countries have experienced large and persistent movements in nominal exchange rates, which are unexplained by macroeconomic fundamentals. Moreover, there is evidence to suggest that the forward foreign exchange rate is a biased and inefficient predictor of future spot exchange rates so that there is a doubt about efficiency in foreign exchange markets. To examine the source of these unexpected movements of exchange rates under the floating system, economists have investigated more directly the behavior of foreign exchange market participants without considering macroeconomic fundamentals (market microstructure approach), and find some important empirical evidence.

2.3.2. Market Micro-Structure Approach

The first thing economists would like to test is whether expectations of market participants are stabilizing or destabilizing. If an appreciation of a currency today is to

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11 In the relevant literature, the phenomenon of nominal exchange rate movements that are not based on economic fundamentals, but rather are based in self-confirming expectations, is also called a 'speculative bubble'.

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induce market agents to forecast depreciation in the future, we call it stabilizing expectation. On the other hand, expectations can be described as destabilizing if agents forecast appreciation tomorrow when they face an appreciation today. In the relevant literature, destabilizing expectation is also called ‘bandwagon behavior’.

Frankel and Froot (1987) presented survey results, which depend on three independent sources between 1976 and 1985. This survey records expectations of five currencies against the dollar (the pound, French franc, mark, Swiss franc, and yen). They found exchange rate expectations do not exhibit ‘bandwagon’ effects at horizons of one year, six months, or three months. In other words, expectations appeared to be stabilizing in the long run. However, subsequent studies indicated that investors at shorter horizons of one week to one month tend to ‘bandwagon’ behavior.

Frankel and Froot (1990) also collected weekly survey data set for four currencies (British pound, German Mark, Japanese yen, and Swiss franc) against the US dollar covering the period of October 1984 to February 1988. They found that, at short horizons (1 week or 1 month), market participants have ‘bandwagon’ expectations. Ito (1990) used the survey data collected by the Japan Center for International Finance (JICF) in Tokyo. This survey was based on telephone surveys conducted twice a month since May 1985. Forecasts of the yen/dollar exchange rate for one, three, and six month horizons were obtained from foreign exchange experts in 44 companies, including 15 banks and brokers, 4 securities companies, 6 trading companies, 9 export-oriented companies, 5 life insurance companies, and 5 imported companies. He found market

\[12\] A more detailed survey of the market microstructure approach is given by Takagi (1991), and Frankel and Rose (1995).
participants appear to have a ‘bandwagon’ expectation in the short run, but a ‘stabilizing’ one in the long run. Froot and Ito (1989) also found a similar result using four different survey data sets.

Another important finding of the market microstructure approach is the widespread influence of ‘chart’ or ‘technical’ analysts in foreign exchange markets. An essential difference between chart analysis and fundamental economic analysis is that chartists study only the price action in the market, while fundamentalists attempt to look behind that action. Chartists believe that the market price represents all information, including economic and non-economic, rational and irrational, simply, all the forces of supply and demand that determine the market price (Allen and Taylor, 1990). In addition, they believe there is some kind of pattern when price would change its trend. Therefore, chartists believe that, from a careful investigation of price itself, we can predict future movements in exchange rates. Consequently, they never conduct forward looking but backward looking behavior to decide their choice.

Frankel and Froot (1990) argue that one of the important reasons underlying overvaluation of the US dollar over the 1981-1985 period was the influence of ‘chartists’ analysis. They present evidence that the weight of chartists in the foreign exchange market has been increasing based on annual Euro-money surveys. For example, in 1978, 18 forecasting firms described themselves as relying exclusively on economic fundamentals, and only 2 on technical or chart analysis, but, by 1985, the positions had been reversed: only one firm reported relying exclusively on fundamentals, and 12 on technical analysis. To extend this survey result, they argue
that, at least in the short-run, the market is dominated by chartists who concentrate on the recent pattern of price movements and their increasing influence may have been a factor in the increased volatility of foreign exchange rates in 1980s. Based on a questionnaire survey in the London market in November 1988, Taylor and Allen (1992) presented their survey results. A key result of their survey was that chartism appears to be most used for forecasting over short time horizons. At the shortest horizons, intra-day to one week, approximately 90 percent of respondents use some chartist input in forming their exchange rate expectations, with 60 percent judging charts to be at least as important as fundamentals. At longer forecast horizons, of one to three months or six months to one year, the weight given to fundamentals increases and at the longest forecast horizons, one year or longer, the skew towards fundamentals is most pronounced, with 30 percent of respondents relying on pure fundamentals and 85 percent judging fundamentals to be more important than charts. They also presented interesting comparison results. The accuracy of chartist predictions was compared with various economic and statistical approaches, using the root mean square error (RMSE) criterion. The models contained the random walk model, ARIMA model, and Vector Autoregressions (VARs) model. Interestingly, they found that one of the chartist predictions outperformed all alternative forecasts based on fundamentals for all currencies. Recently, Lui and Mole (1998) report questionnaire survey results conducted in February 1995 on the use by foreign exchange market dealers in Hong Kong. They found that more than 85 percent of respondents rely on both fundamental and technical analyses for predicting future rate movements at different time horizons.
At shorter horizons, there exists a skew towards reliance on technical analysis as opposed to fundamental analysis, but the skew becomes steadily reversed as the length of horizon considered is extended. Technical analysis is considered slightly more useful in forecasting trends than fundamental analysis, but significantly more useful in predicting turning points.

Overall, empirical evidence indicates that the expectations of foreign exchange market participants are stabilizing in the long run but destabilizing in the short run. In addition, researchers also find a strong influence of technical analysts on determining exchange rates during the floating exchange rate period, especially in the short run. Consequently, evidence from the market microstructure approach implies the possibility of the existence of different types of market participants in foreign exchange markets. This is one of the important motivations of why recent theory deviates from the traditional macroeconomic assumptions that all the participants share the same expectations, and focuses more on the heterogeneity of market participants to explain exchange rate movements (Frankel and Rose, 1995).

Ito (1990) directly investigated the possibility of heterogeneous expectations of foreign exchange market participants. Using JICF survey data, he found that: first, market participants are heterogeneous. There are significant ‘individual effects’ in their expectation formation. Second, the individual effects have characteristics of ‘wishful expectations’: exporters expect yen depreciation, and importers expect yen appreciation relative to others. Third, many institutions are found to be in violation of the rational expectation hypothesis. Most of them underestimated the degree of yen appreciation.
More recently, MacDonald and Marsh (1996) report their empirical results. Using survey data over 150 companies and institutions in the G-7 countries over the period October 1989 to September 1992, they also find there are heterogeneous expectations among market participants.

A number of economists have developed theoretical models which do not depend on traditional macroeconomic assumptions such as rational expectations and representative agents to describe a possible speculative bubble. A typical starting point of these models assumes that market participants use different tools for forecasting exchange rates; for example, some depend more on ‘chart’ analysis and others depend more on economic fundamentals. Goodhart (1988) presents an extensive discussion of how a deviation of the exchange rate from economic fundamentals could occur if various economic agents in the foreign exchange markets depend on different types of model for their predictions. De Grauwe (1996) argues that currency traders are near rational. Thus, there is a range of ‘agnosticism’. With a range of ‘agnosticism’, they use ‘chart’ analysis or trading programs for their decisions without considering underlying economic fundamentals. As a result, the exchange rate will tend to be serially correlated if the changes are small. However, if a large exchange rate change occurs, which deviates from the range of agnosticism, they give more weight to underlying economic fundamentals so that exchange rates finally converge to their long run equilibrium level. Bilson (1990) also proposes a similar argument. De Long et al. (1990, 1991) developed a theoretical model that shows that a ‘noisy trader’ in the

\[^{13}\text{Noisy traders are defined as economic agents basing their expectations solely on past movement of exchange rates such as technical analysis.}\]
foreign exchange market can survive in spite of the existence of rational arbitrageurs in the foreign exchange market. In fact, the implication of their theoretical model is contradictory to Friedman's opinion; price-destabilizing speculators can not survive in the market due to rational arbitrageurs. Moreover, they argue that the unpredictability of 'noise traders' beliefs creates a risk in the price of the asset that deters rational arbitrageurs from aggressive betting against them. As a result, prices can diverge significantly from fundamental values even in the absence of fundamental risk. Bearing a disproportionate amount of risk that they themselves create, enables noise traders to earn a higher expected return than rational investors do. In other words, noise traders can survive in the financial market with rational arbitrageurs. In addition, in some cases, they can earn a higher expected return than rational investors can. Lang et al. (1992) further constructed an empirical model to test four different equilibrium hypotheses including 'efficient' and 'noisy' rational expectations and found evidence supporting the 'noisy' rational expectation hypothesis. On the other hand, some economists also show the possibility of price destabilizing speculation even when speculators are fully informed and have rational expectations. Hart and Kreps (1986) showed that speculative activity, in which all agents are rational, have identical priors, and have access to identical information, can destabilize prices. Stein (1987) extended the Hart and Kreps' model and showed a possibility of welfare loss from speculative markets due to the negative informational externalities.
2.4. Long-term Real Exchange Rate Variability and International Trade

If there has been a cyclical misalignment problem during the floating system, has it been harmful to international commodity trade? It is clear that cyclical misalignment has caused cyclical boom and depression of exporting sectors of a country. For instance, the real depreciation of the US dollar in the 1970's caused increasing US agricultural exports due to additional comparative advantage. On the other hand, real appreciation of the US dollar during the 1980s weakened the comparative advantage position of the US agriculture sector, which caused a harmful effect on US agricultural exports (Tweeten 1989b: Chapter 6). Therefore, we can easily observe the strong effect of exchange rate movements on agricultural trade in the short- and medium-run. However, on theoretical grounds, it is difficult to justify the effect of these cyclical swings of exchange rates on international trade over a long period.

One of the simple but persuasive arguments about the negative effect of cyclical misalignment on international trade comes from the 'political economy effect' of misalignment (Williamson, 1985; De Grauwe, 1988; McKinnon, 1988). The typical argument is as follows. If we assume that an initial overvaluation of a currency occurred, it weakens international competitiveness of a country whose exchange rate is overvalued. Due to loss of competitiveness, some sectors lose their domestic and foreign markets resulting in output and employment losses. Individuals or interest groups that are disadvantaged by overvaluation organize themselves and lobby to pass protectionist legislation. Once it occurs, the protectionist legislation is not easily eliminated, even when the currency tends to depreciate again. On the other hand, some
industries whose currency is undervalued gain from the artificially favorable competitive position. Resources may be induced to enter those industries. When the undervaluation disappears, to avoid sharp cutbacks in their scale of operation, those industries may then have to seek import restrictions or subsidies. Therefore, a sequence of overvaluation and undervaluation over a long period is likely to ratchet up the level of protection. Consequently, countries that have experienced more fluctuation in their exchange rate for a long time period have also experienced lower trade growth rates. Overall, this argument predicts that variability of real exchange rates over periods exceeding a few months or quarters is likely to lead to a reduction in the growth of international trade (De Grauwe, 1988)\textsuperscript{14}.

In more detail, we can explain a two-stage process relating to the interaction between exchange rate appreciation and increased protection. In the first stage, an overvaluation of the real exchange rate leads to increases in import penetration or decreases in exports. Clifton (1985) examined the role of industry-specific real exchange rates in determining import penetration ratios using a partial adjustment model for four different industries (textiles, clothing, iron and steel, and transport equipment) of three developed countries (US, Germany, and UK). He finds, in 8 of 12 individual cases, the estimated coefficients indicate a positive relationship between the real exchange rate and import penetration ratio. In agricultural economics, empirical evidence also suggests that the exchange rate has had an influential effect on US agriculture exports. In his early paper, Schuh (1974) demonstrated that overvaluation of

\textsuperscript{14} It should be noted here that the political economic view of misalignment is not related to the short-term volatility of exchange rates.
the US dollar could have important effects on both exports as well as domestic agricultural prices. Chambers and Just (1981) also find that a 10 percent nominal devaluation of the dollar is associated with a 15, 35, and 7 percent increase in US wheat, corn, and soybean exports in the long run. Tweeten (1989b) argues that unsound monetary and fiscal policies in the 1980s caused real term appreciation of the US dollar, which resulted in a tremendous negative impact on US agricultural exports. Finally, Pick and Vollrath (1994) found empirical evidence of a negative impact of exchange rate misalignment on agricultural export performance in some developing countries. As a whole, it is clear that movements of exchange rates have affected the competitive position of the agricultural sector.

In the second stage, rising import penetration leads to increased protection. The theory of endogenous protection (Hillman, 1982; Mayer, 1984) predicts that, in response to increased import competition, private domestic interests intensify their lobbying activity for protection: higher levels of import penetration will lead to greater protection. Cline (1984) examined the determinants of non-tariff quantitative restrictions at the industry level in five major industrial countries: the US, Canada, the United Kingdom, Germany, and France. He found that, on the basis of the similarity of the coefficients in the individual country equations, the protection process is broadly similar in all five countries. In addition, he also found that the import penetration ratio is the key variable triggering protection, the influence of which is moderated to the extent that the home country is also an exporter of goods in the same industrial category. Trefler (1993) investigated the theory of endogenous protection concentrating
on non-tariff barriers to trade (NTBs) in US manufacturing industry. Treating trade
protection endogenously, he found that NTBs in the US are positively correlated with
import penetration while negatively correlated with exports. Consequently, in 1983
when the US dollar was overvalued substantially, US manufacturing NTBs reduced US
imports by about 50 billion dollars, which was 24 percent of US manufacturing imports.
Lee and Swagel (1997) used disaggregated data on trade flows, production, and trade
barriers for 41 countries in 1988 to examine the political and economic determinants of
protectionism (especially NTBs), as well as the impact of protection on trade flows.
They found that nations tend to protect industries that are weak, in decline, politically
important, or threatened by import competition, but provide less protection to industries
in which exports are important. Larue and Ker (1993), using two different types (i.e.,
parametric and non-parametric) of causality tests, directly examined the relationship
between unanticipated world price variability in agricultural markets and protectionism
in developed countries. They find empirical evidence that unanticipated world price
variability cause protectionism.

In connection with the empirical evidence of price adjustment behavior of
exporting firms, this political economy story also implies different industrial level
effects of exchange rate misalignment. As previously shown, empirical evidence
suggests that even when a home currency is over-valued, foreign exporters do not fully
decrease their export price denominated in the home currency in some manufacturing
industries. Rather, they set their export prices in destination market prices and enjoy
additional profits from such a price strategy. Therefore, import penetration does not

15 Rodrik (1994) surveys a variety of models in which political factors influence trade policy.
quickly increase as much as over-valuation. However, in the agricultural sector, there is a strong possibility that import prices are more sensitively decreased in response to exchange rate movement. In fact, low import prices of foreign goods imply a much larger increase in import penetration, which could cause protectionist legislation. On the other hand, Tweeten (1989b: Chapter 3) discussed the reason why US commercial farmers have had more political power than any other interest group. He suggested that the existence of farm-fundamentalism, fear of food shortages, and their strong organization are important reasons for explaining strong political power of US farmers. If we believe that most of the developed countries have faced a similar situation, this finding also implies that the cyclical misalignment problems have more negatively affected international agriculture trade than any other industry sector.

This political economic story of cyclical exchange rate variability is persuasive. However, to explain a real world phenomenon, at least two conditions should be held. First, the misalignment problem should be large enough to trigger protectionism. Second, over time, a sequence of overvaluation and undervaluation should ratchet up the level of protection. Popularly used voluntarily export restraints (VERs) in most of manufacturing sector trade give us some doubt about this possibility in those industries. In the literature on VERs (i.e., Rosendorff, 1996), exporters already recognize the potential mechanism of protectionist legislation, and, therefore, endogenously determine their export volume.

Empirical research about the effect of the magnitude of misalignment (or long-term real exchange rate variability) on international trade flows is simply sparse. This
is not that strange because economists have only recently rejected the random walk hypothesis of real exchange rates. If the real exchange rate follows a random walk, it implies there is no connection between nominal exchange rate movement and relative prices between countries. Without this connection, we cannot even define the term nominal exchange rate ‘misalignment’ based on relative price levels between countries. The question is simply misalignment from what?

In their sequential papers, De Grauwe and Bellefroid (1986) and De Grauwe (1988) argue that the potentially serious effect of exchange rate movements on international trade is due to relatively long-term real exchange rate variability, which is a proxy variable of the magnitude of misalignment. Using a cross-sectional approach with bilateral trade flows among the ten major developed countries for the fixed exchange rate period 1960-69 and for the flexible exchange rate period 1973-84, they found that long-term real exchange rate variability (or magnitude of misalignment) explains about 20 to 30 percent of the decline in growth of international trade among industrialized countries during the flexible rate period.

However, there are, at least, two potential problems in their empirical studies. The first problem is their measure of the magnitude of misalignment. They used the standard deviation of annual changes of real exchange rates as a proxy measure of the magnitude of misalignment between countries during the sample period. However, I believe that their measure is valid only if countries that have faced larger annual changes in real exchange rates have also faced a larger deviation of nominal exchange rates from economic fundamentals. In fact, there is no reason to believe this is the case.
Second, I do not believe that the standard deviation of annual changes in real exchange rates is a proper proxy variable of the magnitude of misalignment between countries during the fixed exchange rate system. Misalignment problems during the fixed exchange rate system are different from those under the flexible exchange rate system. Unlike exchange rate movements under the floating system, inflexibility of nominal exchange rates caused misalignment problems under the fixed exchange rate system. Therefore, the magnitude of variation in annual changes of the real exchange rates between countries cannot represent the magnitude of misalignment between countries in this case. Without finding the properly aligned nominal exchange rates, it might be more difficult to measure the magnitude of misalignment between countries under the fixed system than under the floating system.

2.5. Discussion

Since the currencies of the major industrial countries were allowed to float in 1973, exchange rates have been determined by foreign exchange market participants. Unlike the beliefs of economists in the 1960s, the new market based system has produced some problems. In this chapter, I briefly reviewed relevant literature concentrating on four different subjects, which is expected to be helpful for understanding the main topic of the present paper. First, in considering the theory of PPP and recent empirical evidence, it has been found that PPP has held among developed countries during the floating system so that real exchange rates have moved toward their equilibrium values in the long run. However, the deviation of nominal exchange rates from PPP has been
substantial, and the speed of convergence has been very slow, which has caused misalignment problems. Second, international commodity traders have adjusted their behavior in facing exchange rate misalignment. Based on industry specific characteristics and international market conditions, the means of adjustment has been different from industry to industry, which is expected to cause different impacts on different industries in the long run. Third, considering the literature of international finance, there is some evidence of inefficiency in foreign exchange markets under the floating system. The evidence of the market microstructure approach suggests that there is heterogeneity of foreign exchange rate market participants. Relevant theory also suggests a possible rational speculative bubble under this assumption. Finally, I reviewed the political economic view about cyclical misalignment problems. Theory and empirical evidence in this area imply a possible negative impact of cyclical misalignment on international trade flows due to increasing protectionism.

Although there has been considerable theoretical development concerning the potential effect of real exchange rate movements at the macroeconomic level, theoretical considerations of its sectoral effects are sparse. In the next chapter, therefore, I will present a theoretical model to show why given exchange rate variability (or magnitude of misalignment) can possibly cause more instability to international agricultural trade than other large-scale manufacturing sectors based on Baldwin and Krugman’s model. Within this framework, we can see why the cyclical misalignment problem could be particularly important for some industry sectors even when the effects are neutral at the macroeconomic level.
CHAPTER 3

THEORETICAL CONSIDERATIONS

Recently, sunk (or menu) cost models have been popularly used to explain the potential linkage between exchange rate variability and international trade\(^1\). Under the assumptions of imperfect competition and existence of initial sunk costs of entering a foreign market, theory shows that exchange rate movements affect entry and exit decisions of exporting firms, which cause real impacts on long-run international trade flows. In this chapter, the basic idea of Baldwin and Krugman's (1989) *hysteresis* model, which is the most influential and the simplest model in this line of literature, will be explained. After that, a simple extension of their model will be introduced to show how a given magnitude of exchange rate misalignment differentially affects trade in different industry sectors. The idea of the extension is simple: all economic agents have faced the same realization of the nominal exchange rate during a long period. However, they do not have the same sunk costs of entering a foreign market. Due to different sunk costs, inaction ranges in response to exchange rate movements are different from

\(^1\) For example, Franke (1991) and Sercu (1992) used these types of model to show the possibility of a positive effect of nominal exchange rate volatility on international trade.
industry to industry, so that the effect of long-term exchange rate variability can possibly be different from industry to industry. Moreover, the importance of the third moment (skewness) of exchange rate distribution will be discussed as a means of examining the validity of the Baldwin and Krugman model in empirical analysis. Finally, the question of how we should interpret the hysteresis model in the time-series sense, and some difficulties of interpreting the model in connection with actual movement of real exchange rates are briefly discussed.

3.1. Hysteresis

To explain the idea of the hysteresis effect of exchange rates, first, I describe a theoretical model introduced by Baldwin and Krugman. The model is based on the following assumptions. First, it is assumed that there is a single foreign firm capable of supplying the home country market in an industry. Second, it is assumed that there is no home competitor, therefore, if the firm decides to enter a home market, it is assumed to be a monopolist. Third, all transactions are assumed to be denominated in the home currency, so that the foreign firm faces all the exchange rate risk. Fourth, if the foreign firm decides to enter the home market, it is assumed to face the following inverse demand function of its product at any time period $t$:

$$p_t = D(q_t),$$  

(3.1)

where $q_t$ is output sold in the home market and $p_t$ is the price denominated in home currency at time $t$.

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2 A more complicated version of the model is suggested by Baldwin (1988).
Under these assumptions, if the firm enters the home market, we can measure its operating profits as:

\[ \pi_i = S_t p_t q_t - c q_t, \]

where \( \pi_i \) is operating profit; \( S_t \) is the spot exchange rate, \( i.e., \) units of foreign currency to buy a unit of home currency; \( c \) is a constant marginal cost calculated in the foreign currency at time period \( t \). Because the nominal exchange rate \( S_t \) is assumed to represent units of foreign currency to buy a unit of home currency, high (low) values of \( S_t \) means a weaker (strong) foreign currency.

To derive the main economic intuition of the model, we need some additional assumptions. That is: there is some sunk cost both entering into and staying in the home market. If the foreign firm is not in the home market, in order to enter into the new market, it must incur some market-entry costs that are sunk. For example, investments in marketing, reputation, and distribution are typical prerequisites for entry. All these costs are summarized as a single entry fee \( N \) in their model. If the firm is already in the market, it also needs some sunk cost such as advertisement cost. The costs of remaining in the market are summarized by a single maintenance cost \( M \). Finally, it is assumed that \( N > M \). In other words, sunk cost for entering the market is bigger than the sunk cost of staying in the market. With these additional assumptions, the foreign firm should face one of the three situations in any given period \( t \), and, net revenues \( R_t \) of the firm in each case become:
(3.3) \[ R_t(S_t) = 0 \quad \text{if the firm chooses not to be in the market} \]
\[ = \pi_t(S_t) - M \quad \text{if the firm was already in the market and} \]
\[ \quad \text{decides to stay there.} \]
\[ = \pi_t(S_t) - N \quad \text{if the firm was out of the market and decides to enter.} \]

Under the assumption of risk \textit{neutrality}, and a constant discount rate \( \delta \), the firm maximizes the expected present value of net revenue so that its objective function becomes:

\[
(3.4) \quad W = E \left\{ \sum_{t=0}^{\infty} R_t(S_t) \delta_t \right\}.
\]

Now, we can easily observe that the long run decision of the firm depends on the behavior of exchange rates \( S_t \). For simplicity, Baldwin and Krugman assume that the spot exchange rate \( S_t \) is a random variable, which is independently and identically distributed (iid) across periods (\( i.e., S_t \sim \text{iid} (S^*, \sigma^2) \)). Where \( S^* \) is an arbitrary equilibrium exchange rate and \( \sigma^2 \) is the variance of \( S_t \). It should be noted here that there is no time subscript on \( S^* \), and \( \sigma^2 \), which means the mean and variance of \( S_t \) are assumed to be time invariant\(^3\). Finally, it is assumed that the value of \( S_t \) is revealed in each period \textit{before} the firm makes its decision whether or not to be in the market.

Finally, in the analysis, a dynamic programming concept is used to examine the firm's decision problem under the given assumption of exchange rate movement. The foreign firm can face basically two possible situations. First, consider a case that the firm was in the home market last period. There are also two options for the firm in this

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\(^3\) In reality, nominal exchange rates should be treated as a random walk so that this iid assumption is unrealistic, although this assumption does not change the main economic implication of the model. For empirical research, real exchange rates will be used instead.
case. First, it can remain in the market. If the firm decides to do so, it will have an expected present value \( \pi(S) - M + \delta V_t \). \( V_t \) is the present value of future revenues of a firm that was in the market the previous period, evaluated before it knows the exchange rate. Under the iid assumption on the exchange rate, the firm can calculate \( V_t \) using a certainty equivalent method: this means calculating the \( V_t \) based on \( E(S_t) = S^* \). Therefore, \( V_t \) will be a fixed number. Alternatively, the firm can exit the home market. In that case, there is no current revenue. However, it still has the option of entering in the future, so its expected present value is \( \delta V_o \), where \( V_o \) is the expected present value of a firm that was out of the market the previous period. Similarly, if the firm was out last period, it also faces two different options. First, it can decide to enter. In this case, its expected present value will be \( \pi(S) - N + \delta V_t \). Alternatively, if it remains out, its expected present value will be \( \delta V_o \).

The optimal strategy of the firm is simple. If the firm was out of the market last period, it should enter if the current exchange rate exceeds an arbitrary critical value, say \( S_1 \). Otherwise, it should stay out. If the firm was in the market last period, it will not exit unless the exchange rate falls below an arbitrary critical value say \( S_0 \). Otherwise, the firm should exit. The critical exchange rates \( S_1 \) and \( S_0 \) can be derived by the condition of indifference between staying and moving with a given initial situation:

\[
\begin{align*}
\pi(S_1) - N + \delta V_t &= \delta V_o \\
\pi(S_0) - M + \delta V_t &= \delta V_o
\end{align*}
\]

From the above condition and iid assumption of exchange rate, equation (3.6) is derived:
\[ \pi(S_1) - \pi(S_0) = N - M > 0. \]

Since \( \pi(S) \) is increasing in \( S \) by definition of exchange rate, equation (3.6) implies that \( S_1 > S_0 \). In other words, the exchange rate that induces new entry is higher than the exchange rate that induces exit. The graphical illustration of the theoretical results are presented in Figure 3.1 where export volume in this industry is shown as a function of the exchange rate. In addition, in order to explain the basic idea of Baldwin and Krugman’s view of the floating exchange rate system, I will explicitly include an arbitrary value of \( \sigma^2 \) into Figure 3.1.

![Figure 3.1: Hysteresis](image-url)
In the figure, the export or import schedule has two parts. If the firm is not in the home market, imports should be equal to zero. This is represented by the schedule \( I \), the horizontal line along the axis \( OS \). If the firm is in the home market, it is true that imports will be an increasing function of the exchange rate. This is shown by the schedule \( II \). Now, the key point of the model is that there is a range of exchange rates, from \( S_0 \) to \( S_I \), where either schedule could apply. For instance, if the foreign firm is not in the market, it will not enter unless the exchange rate goes above the critical value \( S_I \). If it is in the market, then it will stay in so long as the exchange rate does not go below \( S_0 \). Finally, in the figure, I assume that the variance of \( S_t \) is moderate such that \( S_t \) usually falls between \( S_0 \) and \( S_I \), and only rarely lands outside that range. Under this assumption of a given variance of \( S_t \), usually, exchange rate movements do not cause any fundamental structural change in the home market. Occasionally, however, large exchange rate shocks possibly occur, which cause the firm either to enter or exit. Consequently, this large shock will shift the industry to the other segment of the schedule, and cause a fundamental structural change in the exchange rate-export relationship in the long run. Furthermore, without a countervailing large shock, this new market structure is quite persistent. This is the basic concept of hysteresis in the Baldwin and Krugman model.

In fact, Baldwin and Krugman proposed the model to explain why the US trade deficit has been so persistent since the 1980s. According to their view, large overvaluations of the US dollar in the 1980’s induced many new foreign entries in the US market. Simultaneously, it also caused substantial exit of US firms from foreign
markets. Although the US dollar stabilized and found its equilibrium level after the event, new foreign firms could not get out of the US market due to huge initial sunk costs which they paid to enter the US market. In other words, huge unfavorable exchange rate shocks for US exporters caused a structural change in international commodity markets. Moreover, due to the hysteresis effect, this new structure has been persistent so that it can be an important reason as to why the US trade deficit has been so persistent.

However, it is easily observed that they assume the variance of underlying innovation $S_i$ is large enough to generate a huge exchange rate shock as described in Figure 3.1. In fact, Baldwin and Krugman implicitly assumed that a large exchange rate shock has occurred under the floating exchange rate system. This implicit assumption, in fact, has a fundamental role in justifying their model in explaining a real world phenomenon. However, if we believe that the variance of $S_i$ is relatively small so that all the realizations of $S_i$ are within a range between $S_0$ and $S_1$, there is no reason to believe exchange rates have an important role in causing structural change in international commodity markets.

Under the free floating exchange rate system, could foreign exchange markets possibly generate a huge exchange rate shock, which could cause a persistent US trade deficit? There has actually been a debate in the literature about this question. Some economists argue that real exchange rate variability under the pure free floating system has been, occasionally, much larger than the naturally acceptable range (Williamson, 1985, 1987; McKinnon, 1996). As a result, a managed exchange rate system such as
the target zone system used among European Monetary System (EMS) countries (or direct international monetary coordination) is preferred. On the other hand, some economists, following Friedman (1953), seem to believe that misalignment under a pure free floating system has been at a natural level. Therefore, in the long run, it has not been large enough to have a real impact on international trade flows. Simply, although there is a consensus about the existence of cyclical real exchange rate variation (or the misalignment problem) under the flexible exchange rate system, there has been considerable debate about whether this variability has been large enough to negatively affect long run trade growth rates among developed countries. Therefore, the question of whether exchange rate deviation from equilibrium levels has actually caused instability in international trade is ultimately an empirical one.

3. 2. Effects on Different Industries

To extend the model at the industry level, Baldwin and Krugman classify industries by a comparative advantage criterion. For instance, for industries where foreign firms have low costs relative to domestic competitors, we might expect both $S_0$ and $S_I$ to be low; for industries where foreign firms have high costs, both values would tend to be high. However, I find that an alternative criterion might be more useful for showing the main argument of the present study. To show the criterion, I start by discussing the concepts of entry cost ($N$) and maintenance cost ($M$) in the Baldwin and Krugman model. One way to interpret the difference between entry and maintenance cost in the Baldwin and Krugman model is; the entry cost is an initial investment cost,
for instance, a cost to develop a dealer system in the automobile industry. The maintenance cost is a cost of maintaining a reputation, for example, advertising costs. However, if we interpret these costs this way, it might be unclear why new entry in equation (3.3) does not need a maintenance cost ($M$) at period $t$. In other words, it might be logically correct that the new entry needs both the costs of making a dealer system and a cost for advertising. In addition, there is no reason the condition $N > M$ should be satisfied with this interpretation. Therefore, we want to interpret the entry cost in a different way. There are two different parts to the entry cost. The first one might be initial investment cost ($I$), for instance, the cost to develop a dealer system in the automobile industry. The second one is a general maintenance cost like an advertising cost. Therefore, we believe $N = I + M$ might be satisfied. With this modification, we can rewrite equation (3.3) as:

\begin{align}
R_t(S_t) &= 0 & \text{if the firm chooses not to be in the market} \\
&= \pi_t(S_t) - M & \text{if the firm was already in the market and}
\quad \text{decides to stay there} \\
&= \pi_t(S_t) - I - M & \text{if the firm was out of the market and decides to enter.}
\end{align}

and equation (3.5) is rewritten as:

\begin{align}
\pi(S_1) - I - M - \delta V_1 &= \delta V_0. \\
\pi(S_0) - M + \delta V_I &= \delta V_0
\end{align}

Finally, we can rewrite equation (3.6) as

\begin{align}
\pi(S_1) - \pi(S_0) &= I > 0.
\end{align}

With the same logic of Baldwin and Krugman, we can conclude $S_I > S_0$. With our
modification, we can determine the importance of the initial investment \((I)\) in causing hysteresis. Although condition (3.6) gives us only an intuition that \(S_I > S_o\), logically, \(S_I\) and \(S_o\) might be satisfied as a symmetry condition. That is: it might be approximately satisfied that \(S_I - S^* = S^* - S_o\). With this modification, we can classify industries by their differences in initial investment cost \((I)\). Formally, we can classify \(N\) industries that satisfy the following criterion.

\[(3.10) \quad I_1 < I_2 < \cdots < I_N.\]

In other words, this criterion is based on distinguishing industries by their relative difficulties of entry and exit due to initial investment cost. This criteria also implies that there are \(N\) industries that satisfy the following:

\[(3.11) \quad \Delta S' < \Delta S^2 < \cdots < \Delta S^N, \quad \text{where } \Delta S^n = S_i^n - S_o^n.\]

Figure 3.2: Effects of exchange rate movement on different industries
As a special case of this criterion, we will examine two different industries: industry 1 that needs the lowest initial investment cost ($I$) and industry $N$ which needs the highest initial investment cost. Because all the industries face the same exchange rate variability, initially, we can express the situation as in Figure 3.2.

First, I will consider industry $N$. If there were a large nominal exchange rate shock, a structural change would occur. However, even if we accept the possibility that the exchange rate can deviate from market fundamentals, the huge shock-inducing structural change must be a rare phenomenon in this industry. For simplicity, if we assume that the nominal exchange rate shock is always within a range $S_{0}^{N}$ and $S_{1}^{N}$, we might not find an explicit linkage between exchange variability and international trade in this industry. However, the effect of exchange rate variability should be different in the case of industry 1. Given variability in exchange rates can more easily cause instability in this industry. In other words, there is a larger possibility that the given nominal exchange shock can cause structural change for industry 1 than in the case of industry $N$. In addition to that, there might not be a strong motivation for the firm to use a price adjustment strategy because a quick exit or re-entry strategy would be a more proper one due to relatively small initial sunk costs. As a result, we can conjecture that trade of this industry might fluctuate more with movements of nominal exchange rates than that of industry $N$. In general, the agricultural sector could be considered as an example of industry 1. Agricultural products are highly tradable, substitutable, and non-durable. Furthermore, they do not need much initial investment cost to be exported; sunk costs do not matter in the agricultural sector generally.
However, even if we accept the possibility of relatively more instability of commodity trade in industry 1 due to given exchange rate variability, whether this has positively or negatively affected international trade in this industry is still ambiguous. Under the traditional view of risk aversion, the negative effect of real exchange rate variability on trade might be more serious in the case of industry 1 than industry \( N \). However, under the assumption of risk neutrality, a number of authors have proposed the possibility of a positive effect of exchange rate variability on international trade. In the Baldwin and Krugman model, the sign of the effect is also not clearly defined. Therefore, the question of whether the relationship between magnitude of exchange rate variability and international trade in the agricultural sector is positive, negative, or neutral is still an empirical question.

### 3.3. Third Moment of Exchange Rate Distribution

Another empirically important movement of exchange rates connected with the hysteresis model is their third moment: skewness of the distribution of exchange rates. Figure 3.3 shows how the skewness of the distribution of exchange rates could influence international trade with an example of industry \( i \).

\( S'_0 \) represents a critical value of the exchange rate that could cause exit if the firm in industry \( i \) is already in the home market, and \( S'_1 \) represents a critical value of exchange rates that would cause new entry if the firm is not in the market in the previous period. If a firm is in the market over the previous periods, therefore, from \( S'_0 \)
to $S'_i$ represent the firm’s inaction range in response to exchange rate movement. In the figure, the distribution of exchange rates is skewed to the left (but still in an equilibrium level on average), which means the lower tail is larger than the upper tail.

Figure 3.3: Effects of skewness of distribution

In the figure, given the first and second moments, left skewness of the distribution implies the existence of a probability of exchange rate shock inducing exit of the firm, while there is no probability of the shock inducing new entry in this industry. Thus, the hysteresis model suggests the existence of the following possibility: a one-time, large, unfavorable (favorable) exchange rate shock, reflected in left (right) skewness of the
distribution in the figure, might result in a significant decrease (increase) in exports, which is subsequently not recovered through several small favorable (unfavorable) shocks.

In addition, skewness of the distribution also explains the possibility of how the variance of exchange rates interacts with export volume. That is, if the distribution of exchange rate shocks is symmetric, an increase in the variance of shocks magnifies the two tails proportionately so that the effect is not clear on theoretical grounds. However, if the distribution is skewed, a larger variance magnifies the asymmetry in the tails, and thus can affect export volume. In this framework, the variance of exchange rates does not have an independent effect on export volume, but it interacts with skewness. Therefore, a higher variance could cause an increase in export volume when the distribution is skewed to the right, and a decrease in export volume when it is skewed to the left in industry $i$. However, it is important to note that skewness of the exchange rate is not important for some industries such as industry $N$ in the figure because their inaction range is large. In this case, both the second and third moments of the exchange rates distribution could not cause any explicit real impact in this industry. In contrast, the hysteresis model suggests that both the second and third moment of the exchange rates distribution could contain more important information in explaining long run international trade flows for some industries such as industry 1. As a result, we will observe a statistically significant relationship between skewness and export volume only when the given magnitude of misalignment is large enough to effect this industry. Therefore, in considering both the second and third moments of distribution for an
empirical study, we can more directly test the underlying hypothesis of the hysteresis model.

Finally, it might be a natural to ask the question as to what might cause the distribution of shocks to be skewed. In theory, there is no particular answer to this question. However, it is true that skewness of exchange rate shocks can be observed empirically during the post-Bretton Woods era. For instance, the exchange rate shock in the 1980’s for the US dollar was huge, which might cause left skewness of distribution. Although there is no clear answer to the question why this large shock occurred in theory, casual empirical observation suggests the importance of skewness of the exchange rate distribution for empirical study.

3.4. Time-Series Representation of Hysteresis Model

Understanding the hysteresis model in the time-series sense is not easy. This is not because of any difficulty in understanding the model itself, but is due to the difficulty of properly applying the model to explain reality. In this subsection, a proper way to apply the hysteresis model to real world phenomenon will be discussed. First, a time-series representation of the hysteresis model will be described. After that, I will discuss the reason why we should distinguish between two different movements of the exchange rate, long-term variability and short-term volatility, for applying the hysteresis model. Finally, with graphical investigation, I will also briefly discuss why we should distinguish between the persistency and magnitude of misalignment in empirical study.
3.4.1. Time-Series Representation

Within a time-series study, the hysteresis model could be described as in Figure 3.4. Under the assumption of underlying innovation of nominal exchange rates \( S_t \), nominal exchange rates have fluctuated up and down around their long run equilibrium value \( S^* \).

![Time-series representation of the hysteresis model](image)

Figure 3.4: Time-series representation of the hysteresis model.
If the exporter's currency is over-valued, say, higher than $S_i^N$, then an exporting firm in industry N will get out of the market. On the contrary, if the exporter's currency is undervalued, say, lower than $S_o^N$, new entry will occur, which changes the home market structure. This structural change in the home market will be persistent unless the nominal exchange rate is higher than the $S_i^N$ because the new entrant firm would not get out of the market due to its initial sunk cost.

Because exchange rates in the floating exchange regime are endogenously determined by expectations of economic agents, a huge deviation that can induce the structural change of the home market might be a rare phenomenon in this industry. However, if it occurred, the effect might be quite persistent. In the case of industry 1, only moderate deviation can cause structural changes although it is less persistent. This is the basic idea of the hysteresis model in a time-series representation.

Before we go any further, it is desirable to discuss some important points. First, it is important to recognize that there is no time subscript on $S^*$ and $\sigma^2$ in the Baldwin and Krugman model. It implies that their model is not related to the issue of short-term volatility of the exchange rate, but is related to the overall level movement of the exchange rate. Moreover, we can also easily observe that important variables are initial investment costs, which determine the inaction range of the firm, and overall variability of the exchange rate. In fact, time-series movements of real exchange rates (i.e., persistency and short-term volatility) are not treated properly in their model. Second, nominal exchange rates do not have any equilibrium value even in the long run, therefore, real exchange rates should be used for an empirical study. In the 1980s,
empirical evidence suggested that real exchange rates in most developed countries were non-stationary. Thus, the mean and variance of real exchange rates depend on time so that the Baldwin and Krugman model was not testable. However, recent empirical evidence is more favorable to stationarity of real exchange rates, which would support the existence of a finite variance of real exchange rates. For the empirical study in the next chapter, I will use a time-series sample to estimate population moments of each variable. For instance, the population mean of the real exchange rate is estimated from the sample mean of the time-series. Some readers might be curious as to how we can consistently estimate population moments from a single realization. However, some theorems, called ergodic theorems, have been proved that, for most stationary processes, the sample moments of an observed record of length $T$ converge to the corresponding population moments as $T$ goes to infinity (Chatfield, 1975). This is why I continually emphasize the stationarity of real exchange rates.

3.4.2. Long-term Variability and Short-term Volatility

In their studies, some authors (i.e., Franke, 1991; Sercu and Van Hulle, 1992; Sercu, 1992) have used the hysteresis concept for explaining the effect of short-term exchange rate volatility on international trade. As a result, in those models, even monthly volatility of exchange rates could cause new entry and exit from a market. However, as Baldwin and Krugman emphasized in their original paper, a huge

\footnote{Testing whether or not a process is ergodic is impossible from time-series data. Because of that, applied researchers generally assume that a stationary process satisfies ergodicity. For instance, in their empirical studies, De Grauwe and de Bellefroid (1988), Ramey and Ramey (1995), and Romer and Romer (1999), estimate the second moment of the population using a time-series sample. For a more detailed discussion about this statistical issue, see Fuller (1976), and Hamilton (1994: chapters 3 and 7).}
exchange rate shock that could cause an hysteresis effect at the aggregate level should be a once in a life-time phenomenon. Simply, the hysteresis model is not related to short-term volatility of exchange rates, but strongly related to long-term, prolonged swings of exchange rates under the floating system. To explain this point, I simply assume that there are two exchange rate regimes described in figure 3.5.

Figure 3.5: Short-term volatility vs. long-term variability.

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5 Williamson (1985), and Baldwin and Lyons (1994) also emphasize the need to distinguish two different types of exchange rates movements.
In regime one, exchange rates are assumed to be more volatile than those in regime two, while less misaligned than regime two. In contrast, in regime two, exchange rates are assumed to be less volatile than those in regime one, while more misaligned. According to the hysteresis model, in regime one, exchange rate movements do not affect long run entry and exit decisions of a firm for all industry sectors, because the exchange rate moves within a range between $S^i_1$ and $S^i_0$ by assumption. Consequently, there is no reason to believe that the hysteresis model has an important role in explaining real world phenomena in this case. However, in regime two, exchange rate movements can affect long run entry and exit decisions of a firm so that they could play an important role in long run international trade although they are less volatile than those in regime one.

Therefore, to apply the hysteresis model properly, it is important to recognize realized exchange movements under the floating system. For instance, Baldwin and Krugman suggested their model under the view that exchange rates have moved much like regime two while, in the 1960s, economists expected that exchange rates would move much like regime one under the floating system. As discussed in the previous chapter, empirical evidence in this area tells us that nominal exchange rates converge to their long run equilibrium values. However, consensus estimates suggest that the speed of convergence is very slow so that we can not think regime one represents reality. To explain this point directly, I briefly discuss important movements of real exchange rates connected with the key empirical question of the present paper. First, I explain why we should distinguish short-run exchange rate volatility from long-run variability.
3.6 presents the monthly movements in relative consumer price indices (CPI) for the US and Germany, along with nominal and real DM/US $ exchange rates. All data are normalized to June 1973 = 100, and then converted to natural logarithms to avoid possible size distortion.

![Graph](image)

**Figure 3.6:** DM/U.S.$ nominal and real exchange rates, relative prices.

Therefore, a point such as 4.6 on the vertical axis represents a normalized measure of variables at June 1973. It can be easily observed that the nominal DM/US $ exchange rate has diverged from PPP as measured by relative prices. The first cycle
goes from 1977 to 1981, nominal exchange rates falling below PPP, and then reverting to long-run equilibrium by 1981. A second cycle goes from 1981 to 1988, nominal exchange rates rising above PPP, and then reverting to long-run equilibrium by 1988. Movement of the DM/US $ exchange rate has been more stable since 1988. It can also be seen that the real exchange rate follows a similar long cycle, exhibiting mean reverting behavior, with long periods of misalignment. With this example, we can understand two important points. First, we can observe the relationship between real exchange rate and misalignment movements based on the theory of PPP. Simply, if PPP holds in the long run, it is clear that movements of the real exchange rate can be treated as movements of misalignment. Second, it is clear as to the reason why the important issue is not weekly or monthly volatility of exchange rates but cyclical swings of real exchange rates, which last several years.

The majority of empirical studies which have examined the short-term volatility issue with monthly or quarterly time-series data, found its effect to be negligible (Obstfeld, 1995). However, as we can see, those empirical results do not support neutrality of long-term exchange rate variability on international trade because the issues are quite different from each other.

### 3.4.3. Persistency and Magnitude

Next, I briefly discuss why we also need to distinguish persistency from the magnitude of misalignment. To explain this point, in Figure 3.7, movements in four

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However, there is a possibility that countries that have faced higher short-term exchange volatility have also faced a larger misalignment problem during the post-Bretton Woods era. If so, both issues could be related each other. In chapter 5, I will investigate this possibility empirically.
different real exchange rates (French franc, Dutch guilder, UK pound, and US dollar) based on the German mark are presented, where all data are normalized as before.

Figure 3.7: Some real exchange rate movements.

In the figure, we can easily observe that all the series show some degree of persistency of misalignment. In the cases of the pound/DM and the dollar/DM, there are some prolonged cyclical variations in real exchange rates. Similarly, in the case of the franc/DM, we can also observe a cyclical movement of real exchange rates. One
surprising point here is that the guilder/DM shows the most persistent movement in the time-series sense\textsuperscript{7}. We do not even observe mean reverting behavior of the variable if we only consider univariate time-series movement of the data. Therefore, if we believe that the persistent movement of real exchange rates is important, we can conclude that the exchange rate between the Netherlands and Germany is the most problematic during the sample period. Of course, this conclusion is obviously misleading, because we can easily observe that the important point is not the persistency but the magnitude of long run variance. For instance, we can easily observe that the long run real exchange rate variability of the guilder/DM and the franc/DM is much smaller than that of the dollar/DM and the pound/DM. This is why I emphasize cross-country differences in long run real exchange rate variability.

Another way to look at this point is by considering the empirical probability density of real exchange rates, which are considered as a cross-sectional representation of time-series data. For instance, Figure 3.8 presents the empirical probability density of the four real exchange rate movements used previously. Monthly data from January 1970 to March 1999 are used to construct probability densities and the same normalization is used as before. In the figure, 4.6 represents the level of real exchange rates at June 1973. In addition, a smaller value means a real depreciation of the German mark so that implies real appreciation of a partner's currency.

\textsuperscript{7} In fact, I examined the stationarity of the real exchange rates considered in this example using univariate time-series analysis. I found that most of the real exchange rates are stationary except the DM/guilder real exchange rate. Therefore, if we only consider the persistent part of real exchange rate movements, DM/guilder movements might be the most problematic. However, as we can see in figure 3.7, the DM/guilder real exchange rate is the most stable one. Although recently economists emphasize the empirical findings about PPP, the stationarity of the real exchange rate alone is not a sufficient condition in deriving economic intuition.
Figure 3.8: Empirical probability densities of some real exchange rates.

To construct the empirical densities, a nonparametric kernel density method is used\(^8\). Finally, an Epanechnikov kernel with different bandwidths is selected for constructing the empirical densities for each real exchange rate \((h\) in the figures denotes

\(^8\) More detailed explanation about kernel density estimation methods is presented in Wand and Jones (1995).
the selected bandwidths). With these empirical densities, we can also observe some stylized facts in the literature. First, we can easily see that the members of EMS countries have faced relatively small real exchange rate variation during the sample period. As before, long run real exchange rate variability of the guilder/DM and the franc/DM is much smaller than that of the dollar/DM and the pound/DM.

In addition, we can also observe that their real exchange rates have not been that different from those in June 1973 on the sample average. Second, considering the real exchange rate between Germany and US, we can easily observe the existence of left skewness of real exchange rates. Although the real exchange rate between countries has not changed from that of June 1973 on average, substantial US dollar overvaluation in the 1980s strongly affects the shape of the empirical density resulting in left skewness of the distribution. Finally, we can observe why time-series sample moments of normalized real exchange rates can be used for an empirical study.

Recently, many empirical studies of PPP have concentrated on the persistency of real exchange rate movements using a variety of time-series econometric tools. However, persistency alone might not be so harmful to international commodity trade. Simply, if countries have faced a very small variation of real exchange rates (i.e., the guilder/DM or the franc/DM in Figure 3.7), exchange rate movements are not such an important factor in explaining international commodity trade even if these are persistent. In contrast, large variations of real exchange rates could cause cyclical changes in commodity market structure resulting in substantial instability in international trade.
3.5. Discussion

In this chapter, I introduced a basic idea of the hysteresis model suggested by Baldwin and Krugman. Moreover, the possibility of different sectoral effects of exchange rate movements on international trade flows was also discussed. Due to different sunk costs, inaction ranges of entry (exit) decision of firms differ from industry to industry, which cause possible different sectoral effects of exchange rate movements in the long run. With this simple extension of the model, we can derive some testable hypotheses.

First, if cyclical exchange misalignment has been large enough to exceed the inaction range of a firm in an industry during the floating system, exchange rate movements can distort long run international commodity flows, even if they have been mean reverting in the long run. Simply, a one time huge unfavorable exchange rate shock can cause a more destructive impact on an exporter than several moderate favorable shocks. Moreover, due to different inaction ranges in different industries, the effect could be different from industry to industry. This first hypothesis will be tested by considering the skewness of the real exchange rate distribution in the next chapter.

Second, the long run response of commodity trade volumes to the movement of real exchange rates is different from industry to industry due to different initial sunk costs. For instance, in some industries, their inaction ranges are small so that a given cyclical misalignment can affect entry or exit decisions of a firm. Therefore, changes of export volume should be sensitive in response to the movement of real exchange rates. In contrast, in the case of large-scale industries, a given over- (under-) valuation may
not trigger the exit (entry) motive of the firm due to its large irreversible sunk cost. Consequently, changes in trade volume could be relatively stable in response to exchange rate movements. In the next chapter, by considering the first moment of the real exchange rate distribution in the cross-sectional analysis, and level movement in the panel data analysis, I will explicitly test this hypothesis.

Combining this with the political economy view about cyclical misalignment, the following additional hypothesis can be derived. If the cyclical misalignment has been large enough to exceed the inaction range of the firm in an industry, and if it has caused protectionism between countries, which has been ratcheted up, the relationship between long-term real exchange rate variability and trade should be negative. However, the effect may also have been different from industry to industry due to different inaction ranges. In the next chapter, examining the coefficient on the second moment of the real exchange rate distribution, we can test this hypothesis empirically.

Overall, in connection with long run commodity trade flows, the most important factor in exchange misalignment during the floating system must be their overall magnitudes. Even if we believe that misalignment has been relatively persistent, and exchange rates have been extremely volatile in the short-run, we do not expect to observe any effect on international trade in the long run unless misalignment has been large.
CHAPTER 4

EMPIRICAL EVIDENCE

In considering the Baldwin and Krugman model in the previous chapter, I indicated a possibility that large exchange rate misalignment can cause real impacts on international trade flows. Moreover, using a simple extension of their model, I presented a possibility that even a relatively moderate magnitude of misalignment can distort international agricultural trade flows. Although these hypotheses are possible on theoretical grounds, as mentioned earlier, the issue is essentially an empirical one. In this chapter, therefore, I will empirically examine the hypotheses derived from the theoretical consideration in the previous chapter.

The empirical study will be conducted by considering the relationship between long-term real exchange rate variability and trade growth rates in total, and four different industry sectors including the agriculture sector. Three additional industry sectors were chosen based on the scale of industry and characteristics of industry products. The machinery and transport equipment (machinery) and chemical (chemical) sectors are chosen because most of their products are not perfect substitutes
due to some degree of product differentiation, and firms in these industries need a relatively large initial investment cost to enter a foreign market. In short, the industry is considered as industry $N$ in the previous theoretical section. Therefore, it is expected that the inaction range in response to real exchange rate variation is relatively larger than any other industry sector considered here. Consequently, a moderate range of misalignment is not expected to cause any explicit real effect on trade growth rates these sectors. The manufactured goods classified chiefly by material (manufacturing) sector is chosen because its products are almost perfect substitutes by definition of industry. In addition, because most of the products in this industry are likely intermediate goods, it is not expected that the initial investment cost of entry into new foreign markets is an important decision variable. Therefore, this industry is considered as industry 1 in the previous chapter so that the inaction range is relatively small. Consequently, it is expected that even a moderate deviation of the nominal exchange rate from PPP could possibly cause real term instability in trade in this sector.

I will begin this chapter by explaining the variables used in this study. Then, a cross-sectional data approach will be used to examine the relationship between long-term real exchange rate variability and international trade growth for each case. Finally, the same relationship will be examined by using a panel data approach to show the robustness of the link between variables.
4.1. Variable Construction and Data

The focus in this thesis is on the relationship between a long-term real exchange rate variability measure ($\sigma^r_q$) derived from a normalized real exchange rate measure ($r_{qf}$) and export growth rates ($\Delta \ln q^k_{qf}$). The difficulty for this empirical study was the way in which we obtained normalized measures for the variables due to different currency units across sample countries. Therefore, before we go any further, I explain the way I normalized real exchange rates and constructed relevant variables.

The variable $q^k_{qf}$ is the real export value of country $i$ to country $j$ in year $t$ for sector $k$, which is calculated in terms of the exporters' currency, where $k$ refers to a specific export sector. The variable is constructed as follows: using the OECD bilateral trade data set *Trade in Commodities* classified by one-digit standard international trade code (SITC), I get nominal export values from $i$ to $j$ for each sector $k$ in US dollars. This is converted into the exporting country's currency using nominal exchange rates from the International Monetary Fund (IMF) series *International Financial Statistics* (IFS), and deflated by the consumer price index of the exporting country (1982-84=100) from the *Bureau of Labor Statistics* (BLS). The sectors considered in this study are; Total trade (total), Food and live animals (SITC 0: agriculture), Chemical and related products (SITC 5: chemical), Manufactured goods classified chiefly by material (SITC 6: manufacturing), Machinery and transport equipment (SITC 7: machinery). By using growth rates ($\Delta \ln q^k_{qf}$) in the empirical analysis, we can obtain a unified measure of the dependent variable.
The variable $r_{ij}$ is the *normalized* real exchange rate between export country $i$ and import country $j$ at time $t$. The variable is constructed as follows. First, US dollar based real exchange rates, which are based on nominal exchange rate data from the IMF series, deflated by a US/home country consumer price index (normalized 1990=100) were obtained from the Economic Research Service of the US Department of Agriculture (USDA). Bilateral real exchange rates between an exporting and importing country are based on taking the dollar based real exchange rate for the importing country $j$ and dividing by the dollar based real exchange rate for the exporting country $i$ giving the cross-rate $R_{ij}$. However, units of real exchange rates at this stage are different to each other. For instance, real exchange rates between Japan and US are based on the US dollar if exporting country is the US, while it is based on the yen when the exporting country is Japan. Therefore, at the second stage, the real exchange rates series are normalized to 100 in year 1973, which is expressed as $R_{ij}^n$. However, I found that normalized real exchange rates $R_{ij}^n$ are biased measures. For instance, with this measure, a ten-percent real appreciation of the exporter’s currency is not exactly matched by a ten-percent depreciation of the importer’s currency. Therefore, by taking natural logarithms of the series $R_{ij}^n$, we can obtain the series $r_{ij}$ that is unbiased\(^1\).

Finally, the sample of countries includes Belgium-Luxembourg, Canada, France, Germany, Italy, Japan, Netherlands, Switzerland, UK, and US during the time period covering most of the post-Bretton Woods era (1974-1995). Because ten countries’

\(^1\) This bias is similar to the paradox suggested by Seigel (1972).
bilateral trade gives us ninety different bilateral trade flows \((10 \times 9)\) and annual data covering 22 years \((1974-1995)\) for each trade flow, the base samples in this study contain 1980 observations \((90 \times 22)^2\).

Two important points should be emphasized here. First, the choice of the base year is important. By equalizing all the real exchange rate measures in 1973, I actually restrict the nominal exchange rates among sample countries in 1973 to be the properly aligned nominal exchange rates based on PPP. This restriction also means that real exchange rates in 1973 were long run equilibrium rates among sample countries. This choice of base year is followed by Williamson (1985). The underlying rationale of the choice is that, at the starting year of the floating exchange rate system, most developed countries decided their exchange rates using bilateral agreement. Therefore, nominal exchange rates in 1973 could represent properly aligned exchange rates. However, except for this intuitive reason, there is no theoretical reason why we believe real exchange rates among the sample countries are at their long run equilibrium level in 1973. In fact, no economists know when nominal exchange rates have been perfectly aligned based on PPP among the sample countries, and this is the reason why measuring misalignment is intrinsically imprecise. However, I do not believe this normalization causes a serious bias. If our main variable is the first moment of real exchange rates, the choice of the base year is quite important. However, the main variable considered in this study is the second moment of the distribution of real exchange rates. Thus, if

\(^2\) These countries are, in fact, G10 countries and were also used by De Grauwe and de Bellefroid for their earlier study. Taken together these countries accounted for 57 percent of total world imports of agricultural goods, and around 46 percent of total world exports at the mid-point of the sample period, 1985.
we choose a base year uniformly for each cross-country pair, the relative cross-sectional magnitude of the second moment of real exchange rate distribution could represent a normalized proxy measure of relative long-term real exchange rate variability for each cross-country pair. Second, it is important to note at this point that the sample consists of countries that have had different international monetary systems during the post-Bretton Woods era. Most of the European countries in the sample have used a managed floating exchange rate system since 1979 under the European Monetary System (EMS). In contrast, other countries, including the US, have generally operated under a pure free-floating system. However, it is also true that even among the EMS countries, allowed target zones have been different from country to country based on their bilateral agreements. And, even among non-EMS countries, the degree of international coordination to stabilize the exchange rate variation has been different to each other. Therefore, with this mixed sample, it is also possible to examine whether different monetary systems have had an important role in explaining long-run trade growth rates among the sample countries.

4.2. Cross-Sectional Approach

To begin, I ran a simple regression between long-term real exchange rate variability and export growth rates using a cross-sectional method, and then further examined the robustness of the link with additional control variables added to the regression model. A cross-sectional approach is used because long-run real exchange

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3 Later in the chapter, I will consider a case where we use an alternative normalization of real exchange rates based on the restriction that real exchange rates are at long run equilibrium at the sample average during the sample period.
variability is treated as a time-invariant variable. As discussed earlier, real exchange rates have deviated from their long-run equilibrium during the post-Bretton Woods era, the deviation being pretty persistent. Therefore, from a practical standpoint, obtaining a time-varying measure of long-term real exchange rate variability is difficult due to the short span of the floating exchange rate system. In addition, there is an underlying statistical rationale for treating real exchange rate variability as a time-invariant variable. Recent empirical evidence of long-run PPP indicates that real exchange rates among most developed countries can be characterized as a stationary process. According to the theory of time-series statistics, stationarity of a variable implies the existence of a finite long-run variance of the series. As discussed earlier, by ergodicity theory, we can use a sample of time series data for estimating the true population moments of a stationary process. I believe that the cross-country differences in long run variances (or standard deviations) of real exchange rates could more closely represent the magnitude of misalignment countries faced during the post-Bretton Woods era than the existing measures such as the standard deviation of annual changes in the real exchange rate. With this treatment of long-term real exchange rate variability, each bilateral real exchange rate during the sample period gives us only one datum as a measure of magnitude of misalignment, so that the variable is treated as a time-invariant variable. In fact, this treatment of real exchange variability is a distinguishable feature of the present study compared to other studies that consider time-varying short-term

4 If real exchange rates are a non-stationary process, their variances are time dependent so that long run variances go to infinity when time goes to infinity. Therefore, in this case, we can not even define the long run variance of real exchange rates. As a result, measuring long term real exchange rate variability is impossible. This is an important reason why empirical studies examining the misalignment issue have been so rare.
volatility of real exchange rates\(^5\). As the main variable for the study is treated as time-invariant, examining the linkage between variables with a cross-sectional approach is a natural choice.

4.2.1. Simple Correlations

Initially, the following simple cross-sectional model is estimated for each of the sectors:

\[
\Delta \ln q_{jt}^k = \alpha_{0k}^k + \alpha_{1k}^k \bar{v}_j^k + \varepsilon_{jk}^k,
\]

where \(k = 1, 2, 3, 4, 5\); 1 = total export, 2 = agriculture, 3 = manufacturing, 4 = machinery, 5 = chemical; \(\Delta\) is the usual first difference operator. \(\bar{g}\) is the time average of any variable \(g\) so that \(\Delta \ln q_{jt}^k\) is the sample average of the annual export growth rate of industry \(k\) from exporting country \(i\) to importing country \(j\) over the sample period. \(\bar{\sigma}_j^k\) is the standard deviation of the real exchange rate during the sample period, which is a proxy measure of the magnitude of nominal exchange rate misalignment between countries.

Table 4.1 shows the regression results along with two correlation coefficients between variables. The first correlation coefficient is the popularly used Pearson correlation coefficient. An alternative measure of correlation is the Spearman rank correlation, which is not as sensitive to extreme values in the sample\(^6\). The first

\(^5\) In fact, some authors, \(i.e.,\) Ramey and Ramey (1995), and Romer and Romer (1999), treat uncertainty (instability) due to the long-term business cycle as a time invariant variable for their empirical study, and then use a cross-sectional approach. Potentially, they might face the same difficulty as the present study.

\(^6\) For further details about Spearman rank correlation coefficients, see Gujarati (1995).
important finding is that: in the case of total trade, no statistically significant relationship between variables is found. The estimated $t$-statistic on real exchange rate variation is 0.55, so that we can not reject the null hypothesis of no relationship at the 10 percent level. In addition, the correlation coefficients are 0.051 and 0.096 respectively, indicating almost no correlation between variables.

<table>
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<th>Total</th>
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<th>Chemical</th>
<th>Manufacturing</th>
<th>Agriculture</th>
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<td>0.045$^a$</td>
<td>0.027$^a$</td>
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<td>-0.342$^a$</td>
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<td>(-2.02)</td>
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<td>Correlation coefficient</td>
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<td>0.055</td>
<td>-0.254</td>
<td>-0.365</td>
</tr>
<tr>
<td>(Spearman)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Notes:* Ordinary Least Squares (OLS) estimator with heteroskedastic consistent covariance matrix (White 1980) used to calculate standard deviation. $t$-ratios are in parenthesis; $a$ and $b$ denote significance at the 1 and 5 percent level

Table 4.1: Correlation between average export growth and real exchange rate variability (sample size=90).

As discussed earlier, this lack of correlation could give us an important intuition in connection with the recent debate over international monetary reform. In fact, this result implies different monetary systems among sample countries during the post-Bretton Woods era have not had an important role in explaining cross-country
differences in export growth rates at the aggregate level. In connection with the Baldwin and Krugman model, it can be also interpreted as showing that the magnitude of misalignment under the pure free floating system has not been large enough to explicitly affect long run total trade growth rates among developed countries. In their earlier study, De Grauwe and de Bellefroid (1986) found a significant negative relationship between variables using a sample of 1973-1984 with the same country pairs, but employing a different measure of the magnitude of misalignment. With 11 more years in the sample, we find a contradictory result to theirs.

In spite of the long run neutrality of exchange rates on total trade, I find the relationships are significant for sectoral trade. In the case of the agriculture and manufacturing sectors, the relationship between variables is negative and statistically significant. The estimated t-statistics are -4.01 and -2.02 respectively, so that we can reject the null hypothesis of no relationship at the 1 and 5 percent level. In contrast, for the machinery sector, the relationship is rather positive. The estimated t-statistic is 2.56, indicating that there is a statistically significant positive relationship between mean export growth and real exchange rate variation. The estimated coefficients imply that a one unit increase in the measure of real exchange rate variability is associated with a 9 percent increase in trade growth rates in the machinery sector, an 11 percent reduction in trade growth in the manufacturing sector, and a 34 percent reduction in trade growth in the agricultural sector. Compared to the other exporting sectors, the sensitivity of the growth in agricultural sector trade in response to real exchange rate variation is much larger.
4.2.2. Robustness

Considering simple correlations between variables, we find two important results. First, we did not find any statistically significant relationship between the total export growth rate and long-term real exchange rate variability over the period 1974-1995. This result is quite different from the earlier estimation results of De Grauwe and de Bellefroid. Moreover, the results also imply that different international coordination to manage nominal exchange rates has not been an important variable in explaining long run trade growth rates among the sample countries at the aggregate level. Second, however, we found statistically significant, but asymmetric relationships between variables at the industrial level. Negative correlation was observed in the case of the agriculture and manufacturing sectors while positive correlation is observed in the case of the machinery sector.

Although these results are interesting in relation to the theoretical consideration in the previous chapter, at this point, it is inappropriate to accept these simple correlations as evidence of differing effects of long-term real exchange rate variation across sectors. In order to examine the robustness of the link, it is necessary to add control variables. In line with the recent paper by Rose (2000), and the literature on the gravity equation (Anderson, 1979; Bergstrand, 1985; Hummels and Levinsohn, 1995), the annual average growth rate in the product of the real income of the exporting country $i$, and the importing country $j$ over the sample period is included, $\Delta \ln y_{it} y_{jt}$. The variable is expected to pick up both demand and supply side effects on the growth of trade. This variable is collected from the IMF series International Financial Statistics, (line 99b),
the series already being deflated (1990=100). Because an increase in income growth rates of two trading partners is expected to cause an increase in bilateral trade, it is expected that the sign of the coefficient is positive.

Two additional control variables are derived from the real exchange rate measure: specifically, the first and third moments of the real exchange rate distribution. In terms of the first moment, although recent empirical evidence suggests that the underlying process of real exchange rates is mean reverting, in reality, the \textit{ex-post} realization of real exchange rates during the sample period could be asymmetric. For example, overvaluation of the US dollar over the period 1982-1986 was both substantial and persistent. As a result, without any countervailing movement of the US dollar (\textit{i.e.}, an undervaluation of similar magnitude), this event could dominate the average US dollar movement during the sample period that can generate an overvaluation of the US dollar compared to some trading partners even on average. In other words, stationarity of real exchange rates does not guarantee that \textit{ex-post} realization of real exchange rates is perfectly symmetric, and, as a result, the real exchange rate does not necessarily exactly converge to its long run equilibrium level at the sample average. Therefore, the average real exchange rate during the sample period, \( \bar{r}_{gt} \), is included in the regression model. Because higher values of the real exchange rate measure represents real appreciation of an exporter’s currency, the sign of the coefficient is expected to be negative.

\footnote{In fact, I included only importer’s income growth rate into the regression equation at first. Unfortunately, the estimated coefficient in the case of agriculture trade growth was unacceptably high due to small sample bias. Furthermore, I also included both importer’s and exporter’s incomes separately into the model, which does not mitigate the small sample bias as we expected. However, in any specification, the estimated results on the exchange rate variables were not changed substantially.}
The second control variable is the third moment of real exchange rates (i.e., skewness of the distribution of real exchange rates, \( \text{skew}_{y} \)). While real exchange rates revert, on average, to their long-run equilibrium level, the possibility exists that a one-time, large, unfavorable (favorable) exchange rate shock might result in a significant decrease (increase) in exports, which is subsequently not recovered through several small favorable (unfavorable) shocks. This is essentially an extension of the hysteresis model: a one-time, large, unfavorable (favorable) exchange rate shock, reflected in right (left) skewness of the distribution, will induce significant exit (entry) of exporting firms in destination markets, and subsequent small favorable (unfavorable) exchange rate shocks will not induce an equivalent amount of entry (exit) into the market. Moreover, skewness might not be important to some industries due to their inaction range being very large, such as industry \( N \) in the previous chapter. Because right skewness of a distribution indicates large unfavorable exchange rates shock for the exporter in the present study, we expect the sign of the variable to be negative if the hysteresis model is valid.

Given these additional variables, the following cross-sectional model is estimated:

\[
\Delta \ln q_{yt}^{k} = \alpha_{0}^{k} + \alpha_{1}^{k} r_{yt} + \alpha_{2}^{k} \hat{\sigma}' + \alpha_{3}^{k} \text{skew}_{y}^{r} + \alpha_{4}^{k} \Delta \ln y_{yt} + \varepsilon_{yt}^{k}
\]  

\( ^{8} \) Of course, there are other potentially important variables that could affect export growth rates such as changing relative productivity growth rates, changing trade policies, and changing tastes. Due to data limitations, however, I cannot include these variables into the regression model, which are expected to remain as estimation errors.

\( ^{9} \) Initially, an EU dummy variable was included in the model. However, because all EMS countries considered in this study are also members of the EU, there is a strong negative correlation (-0.60) between the measure of misalignment and the EU dummy variable. The estimated coefficient on long-term real exchange rate variability is sensitive to estimation with and without the EU dummy variable into the model. This is an obvious symptom of multicollinearity between two variables. Therefore, the EU dummy variable was eliminated from the regression.
The estimation results for the whole sample are shown in Table 4.2. In the case of the average real exchange rate measure, we can reject the null hypothesis of no relationship at the 1 percent level for all cases, and the sign of estimated coefficients are negative as expected. However, some care should be taken in interpreting these results.

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Machinery</th>
<th>Chemical</th>
<th>Manufacturing</th>
<th>Agriculture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.140a</td>
<td>0.189a</td>
<td>0.082</td>
<td>0.288a</td>
<td>0.615a</td>
</tr>
<tr>
<td></td>
<td>(2.80)</td>
<td>(3.53)</td>
<td>(1.13)</td>
<td>(4.10)</td>
<td>(5.19)</td>
</tr>
<tr>
<td>Average real</td>
<td>-0.028a</td>
<td>-0.043a</td>
<td>-0.008</td>
<td>-0.058a</td>
<td>-0.122a</td>
</tr>
<tr>
<td>exchange rates</td>
<td>(-2.64)</td>
<td>(-3.99)</td>
<td>(-0.59)</td>
<td>(-4.19)</td>
<td>(-5.07)</td>
</tr>
<tr>
<td>STD of real</td>
<td>-0.010</td>
<td>0.028</td>
<td>-0.003</td>
<td>-0.117b</td>
<td>-0.331a</td>
</tr>
<tr>
<td>exchange rates</td>
<td>(-0.36)</td>
<td>(0.88)</td>
<td>(-0.07)</td>
<td>(-2.41)</td>
<td>(-5.62)</td>
</tr>
<tr>
<td>SKEW of real</td>
<td>-0.038</td>
<td>-0.014</td>
<td>-0.059b</td>
<td>-0.085b</td>
<td>-0.181b</td>
</tr>
<tr>
<td>exchange rates</td>
<td>(-1.47)</td>
<td>(-0.46)</td>
<td>(-2.15)</td>
<td>(-2.17)</td>
<td>(-2.48)</td>
</tr>
<tr>
<td>Average income</td>
<td>0.400</td>
<td>0.971a</td>
<td>0.054</td>
<td>0.175</td>
<td>-0.164</td>
</tr>
<tr>
<td>growth rates</td>
<td>(1.49)</td>
<td>(3.47)</td>
<td>(0.14)</td>
<td>(0.37)</td>
<td>(-0.27)</td>
</tr>
<tr>
<td>( R^2 )</td>
<td>0.117</td>
<td>0.265</td>
<td>0.025</td>
<td>0.220</td>
<td>0.370</td>
</tr>
</tbody>
</table>

Notes: Ordinary Least Squares (OLS) estimator with heteroskedastic consistent covariance matrix (White 1980) used to calculate standard deviation. \( t \)-ratios in parenthesis; a, and b denote significant at the 1 and 5 percent level.

Table 4.2: Average export growth and real exchange rate variability (sample size=90).

To normalize real exchange rates, it has been assumed that real exchange rates were at their long-run equilibrium level in 1973. Although this normalization does not undermine one's basic intuition concerning the results, it can distort the main intuition of the estimation results as there is no particular theoretical reason why 1973 real exchange rates represent properly aligned real exchange rates. If we believe long run
equilibrium real exchange rates should be calculated at the sample average, given recent empirical evidence of mean reverting behavior, the variable should be eliminated from the regression model due to perfect collinearity with the constant term\textsuperscript{10}.

Although the theoretical rationale of including the average real exchange rate measure into the cross sectional model is not clear, the estimation results give us an interesting economic implication. Simply, the response of trade growth rates to real exchange rates is highest for agriculture among the sectors considered here. The estimated coefficients imply that a one-unit appreciation (depreciation) in the average real exchange rate index during the sample period is associated with a 2.8 percent decrease (increase) in total export growth rates, compared to a 12 percent decrease (increase) for the agriculture sector. This result could be interpreted as being consistent with the belief of many agricultural economists (\textit{i.e.}, Chambers and Just, 1981) that real exchange rate variation may cause more instability in agricultural trade compared to total trade.

In the case of skewness of the real exchange rate distribution, the estimated coefficients are statistically significant in the case of the chemical, agriculture, and manufacturing sectors. The results indicate that a large real appreciation of a currency, although a rare occurrence, has a more unfavorable effect on exports than a small real depreciation of a currency, which is a more frequent occurrence. The estimated coefficients imply that a one-unit increase in right skewness of the distribution of real exchange rates is associated with a 5.9 percent decrease in export growth rates in the case of the chemical sector, a 8.5 percent reduction in exporting growth rate in the case

\textsuperscript{10} I will consider this case later in this chapter with an alternative normalized real exchange rate measure.
of the manufacturing sector, and a 18.1 percent reduction in export growth rates in the case of the agriculture sector. Interestingly, the country that has faced the most right skewness in the distribution of real exchange rates is the US and the estimated skewness measure is 0.051. The associated reduction in US export growth rates is about 0.93 percent in the agriculture sector, about 0.44 percent in the manufacturing sector, and 0.30 percent in the chemical sector. These results indicate that significant overvaluation of the US dollar in the mid-1980s had a significant impact on US agricultural exports. Although, after this event, the US dollar has occasionally experienced moderate real depreciation, this has not been enough to generate a recovery in export growth rates of the US agricultural sector.

The annual average growth rate in real income is statistically significant only for the case of the machinery sector. The estimated coefficient is 0.971. This implies that a 1 percent increase in annual average income growth rates of two trading partners is associated with almost the same amount of trade growth rate between two countries in the case of the machinery sector.**

Finally, with respect to the standard deviation of real exchange rates, the results do not change very much when compared to those reported in Table 4.1. The only exception is that now we do not have the positive sign between variables in the case of the machinery sector. Therefore, in the case of total, machinery, and chemical sector

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** By employing the Chow test, I also checked the structural differences between sectors. And, the test results strongly reject the null of the same structure between sectors. For instance, the estimated F-statistic is 20.6 when I check the structural difference between machinery and agricultural sectors, which rejects the null of the same structure at the 1 percent level. In the case of the manufacturing and agricultural sectors, the estimated F-statistic is 3.47. Although the estimated F-statistic is much lower than that between the machinery and agricultural sectors, we can also reject the null hypothesis at the 1 percent level.

86
trade, the estimated coefficient on real exchange rate variability is not statistically significant, while the signs on the coefficients are negative, and statistically significant in the case of the manufacturing and agriculture sectors. The estimated coefficients imply that a one-unit increase in standard deviation of real exchange rates is associated with a 11.7 percent decrease in export growth rates in the case of the manufacturing sector and a 33.1 percent reduction in exporting growth rate in the case of the agriculture sector.

Given the different monetary systems in place during the sample period, the results for EMS and non-EMS country trade are compared in Table 4.3, where, for the whole sample, EMS, and non-EMS cases, the sample average of export growth rates in each sector is presented, along with the sample average of the standard deviation of normalized real exchange rates. The calculated average standard deviation of real exchange rates among EMS countries is 0.073, which is lower than the whole sample average of 0.139, and that of the non-EMS case, 0.157. In the case of the manufacturing sector, these figures are associated with a 1.6 percent reduction of trade growth as a whole, a 0.85 percent reduction in the case of EMS countries, and a 1.84 percent reduction in the case of the non-EMS countries. In the case of the agricultural sector, the negative relationship is much stronger. The calculated long-term real exchange rate variations are associated with about a 4.6 percent reduction of agriculture trade growth as a whole, a 2.4 percent reduction in the case of the EMS countries, and a 5.2 percent reduction in the case of the non-EMS countries.
Table 4.3: Sample average of the variables

<table>
<thead>
<tr>
<th></th>
<th>EMS</th>
<th>non-EMS case</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>2.57</td>
<td>2.90</td>
<td>2.86</td>
</tr>
<tr>
<td>Machinery</td>
<td>3.49</td>
<td>4.05</td>
<td>3.93</td>
</tr>
<tr>
<td>Chemical</td>
<td>4.08</td>
<td>4.62</td>
<td>4.50</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>1.48</td>
<td>1.11</td>
<td>1.19</td>
</tr>
<tr>
<td>Agriculture</td>
<td>2.61</td>
<td>-0.55</td>
<td>0.15</td>
</tr>
<tr>
<td>STD of real exchange rates</td>
<td>0.073</td>
<td>0.157</td>
<td>0.139</td>
</tr>
</tbody>
</table>

4.2.2.1. Non-EMS Sub-sample

It should be noted that over this period, all EMS countries were also members of the European Union (EU). These countries have also applied an integrated agricultural policy under the auspices of the Common Agricultural Policy (CAP). It is possible, therefore, that the previous results relating to the agriculture sector are due to agricultural policy rather than monetary coordination.\(^\text{12}\) Due to a potential multicollinearity problem, however, I could not control the customs union effect on the trade growth rate in the previous regression. To handle this problem, bilateral trade between EMS countries is removed from the sample and the regression re-run. In this case, though, a dummy variable is added to represent trade between the UK and other EU members because while the UK is a member of the EU, it has not been a member of

---

\(^\text{12}\) It is also possible that through the use of green rates, the CAP insulated domestic farm prices from radical swings in exchange rates over this time period.
the EMS for the complete sample period. The following model is estimated with this sub-sample:

\[
\Delta \ln q_{it}^k = \alpha_0^k + \alpha_1^k r_{it}^k + \alpha_2^k \tilde{G}_i^r + \alpha_3^k \text{skew}_{y_i}^r + \alpha_4^k \Delta \ln y_{it} + \alpha_5^k EU + \varepsilon_{it}^k,
\]

EU being the dummy variable, and all the other variables are as previously defined.

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Machinery</th>
<th>Chemical</th>
<th>Manufacturing</th>
<th>Agriculture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.126(^a)</td>
<td>0.185(^a)</td>
<td>0.062()</td>
<td>0.270(^a)</td>
<td>0.588(^a)</td>
</tr>
<tr>
<td></td>
<td>(2.75)</td>
<td>(3.62)</td>
<td>(0.90)</td>
<td>(4.57)</td>
<td>(5.33)</td>
</tr>
<tr>
<td>Average real</td>
<td>-0.029(^a)</td>
<td>-0.045(^a)</td>
<td>-0.009()</td>
<td>-0.059(^a)</td>
<td>-0.124(^a)</td>
</tr>
<tr>
<td>exchange rates</td>
<td>(-3.03)</td>
<td>(-4.47)</td>
<td>(-0.68)</td>
<td>(-4.79)</td>
<td>(-5.40)</td>
</tr>
<tr>
<td>STD of real</td>
<td>-0.094(^b)</td>
<td>-0.003()</td>
<td>-0.125()</td>
<td>-0.321(^a)</td>
<td>-0.360(^a)</td>
</tr>
<tr>
<td>exchange rates</td>
<td>(-2.05)</td>
<td>(-0.05)</td>
<td>(-1.52)</td>
<td>(-4.61)</td>
<td>(-2.87)</td>
</tr>
<tr>
<td>SKEW of real</td>
<td>-0.056(^b)</td>
<td>-0.044()</td>
<td>-0.071(^b)</td>
<td>-0.105(^a)</td>
<td>-0.248(^a)</td>
</tr>
<tr>
<td>exchange rates</td>
<td>(-2.19)</td>
<td>(-1.31)</td>
<td>(-2.19)</td>
<td>(-2.84)</td>
<td>(-2.92)</td>
</tr>
<tr>
<td>Average income</td>
<td>1.052(^a)</td>
<td>1.375(^a)</td>
<td>0.921(^c)</td>
<td>1.333(^a)</td>
<td>0.592</td>
</tr>
<tr>
<td>growth rates</td>
<td>(3.72)</td>
<td>(4.19)</td>
<td>(1.98)</td>
<td>(2.60)</td>
<td>(0.78)</td>
</tr>
<tr>
<td>EU</td>
<td>0.027(^a)</td>
<td>0.026(^a)</td>
<td>0.029(^a)</td>
<td>0.031(^a)</td>
<td>0.052(^a)</td>
</tr>
<tr>
<td></td>
<td>(7.48)</td>
<td>(5.83)</td>
<td>(4.73)</td>
<td>(6.27)</td>
<td>(4.40)</td>
</tr>
<tr>
<td>(R^2)</td>
<td>0.408</td>
<td>0.428</td>
<td>0.225</td>
<td>0.485</td>
<td>0.477</td>
</tr>
</tbody>
</table>

*Notes* Ordinary Least Squares (OLS) estimator with heteroskedastic consistent covariance matrix (White 1980) used to calculate standard deviation. \(t\)-ratios are in parenthesis; \(^a\), \(^b\), and \(^c\) denote significant at the 1, 5, and 10 percent level.

Table 4.4: Average export growth and real exchange rate variability: non-EMS case (sample size=70).

---

\(^{13}\) In this sub-sample, there is little collinearity between real exchange rate variation and the EU dummy.

89
The estimation results, reported in Table 4.4, are similar to those for the whole sample. An important difference, however, is the evidence, in the total case, for a negative impact on annual average export growth rates of the second and third moments of the real exchange rate distribution. The estimated t-statistics are -2.05 and -2.19 respectively so that we can reject the null hypothesis at the 5 percent level. Again, there is some evidence that overvaluation of the US dollar in the 1980s has more negatively affected US export growth rates than subsequent moderate depreciation of the dollar even in the case of total exports, providing some support for Baldwin and Krugman’s hypothesis. However, in an economic sense, the effect seems not to be so significant in the case of total trade. For instance, as mentioned before, the country that has faced the most right skewness in the distribution of real exchange rates is the US and the estimated skewness measure is 0.051. The corresponding loss of export growth in the case of total trade is only 0.29 percent, which is not that significant. On the other hand, with this sub-sample, loss of export growth rate in the case of the US agricultural sector becomes 1.27 percent, which is not negligible in an economic sense. The important point we obtained here is that, by considering only the data of non-EMS countries, we can confirm that the results of the whole sample are not due to the customs union effect among members of the EU.

Another interesting difference is that all the statistical indicators such as $R$-squares and $t$-ratios increased substantially in this sub-sample compared to those for the whole sample. There could be two potential reasons for this stronger statistical power of the regression model. The first one is due to the additional EU dummy variable. Including
an additional important variable into the model increases the overall statistical power of
the model. The second reason could be possibly due to irrelevance of real exchange
rate movement and trade growth rates among EMS countries. That is, if EMS countries
have efficiently intervened in the foreign exchange market and substantially stabilized
their bilateral exchange rates based on PPP, we might not expect that real exchange rate
movements contain important information for explaining long run trade growth rates
among EMS countries. In other words, there is a possibility that long run exchange rate
neutrality has been achieved by proper monetary coordination among EMS countries.
If so, it is possible that including irrelevant cases into the sample, statistical power of
the whole sample could be substantially decreased.\(^{14}\)

4.2.3. An Alternative Measure of Magnitude of Misalignment

According to the recent empirical evidence of stationarity of real exchange rates,
real exchange rates among developed countries converge to their long run equilibrium
level, which could be approximated at their sample averages. Although stationarity of
real exchange rates might not imply exact mean reverting *ex-post realization* of real
exchange rates, in this section, an alternative measure of real exchange rates will be
used to examine the robustness of the link between variables.

An alternative normalization procedure is used to obtain a uniform measure of the
real exchange rate. At the first stage, the bilateral real exchange rates \(R_{xy}\) were
calculated as discussed earlier. At the second stage, by taking a natural logarithm \(R_{yl}\),

\(^{14}\) Because the sample size of inter-EMS trade is too small, I do not explicitly examine this case separately.
we can obtain non-normalized measure of real rates, \( \ln R_{yt} \). To normalize, all cross-sectional real rates are equalized at their sample averages, deviations of real rates from their cross-sectional sample averages (\( r_{yt}^d = \ln R_{yt} - \ln R_{yt} \)) were then calculated. In an economic sense, the measure \( r_{yt}^d \) represents the time-series movement of percent changes of real exchange rates from their long run equilibrium level approximated by their sample average. Finally, the alternative measures of misalignment (\( \bar{\delta}_{yt}^d \)) and skewness of distribution (\( \text{skew}_{yt}^d \)) are estimated based on \( r_{yt}^d \). The important difference between the alternative measure from that previously used, is that all the normalized measures of real exchange rates \( r_{yt}^d \) converge to zero at their sample average. Therefore, in the cross-sectional study, average real exchange rate movement can not be included in the regression equation because of a perfect multi-collinearity problem with the constant term.

With these alternatively measured variables, the following cross-sectional regression model is estimated for each of the sectors:

\[
(4.4) \quad \Delta \ln q_{yt}^k = \beta_0^k + \beta_1^k \bar{\delta}_{yt}^d + \beta_2^k \text{skew}_{yt}^d + \beta_3^k \Delta \ln y_{yt}y_{yt} + \varepsilon_{yt}^k
\]

The estimation results for the whole sample are shown in Table 4.5. As a whole, the regression results with the alternative measure do not change the basic economic implications of the previous model. However, statistical power of the model is decreased substantially. In the case of the agriculture and manufacturing sectors, the estimated coefficients on STD of real exchange rates are still negative and statistically significant at the 5 and 1 percent levels. The skewness of distribution is also negatively
associated with export growth rates in those sectors as well as the chemical sector. In the case of total, machinery, and chemical trade, no statistically significant relationship between export growth and misalignment measure is found.

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Machinery</th>
<th>Chemical</th>
<th>Manufacturing</th>
<th>Agriculture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.012</td>
<td>-0.009</td>
<td>0.043</td>
<td>0.021</td>
<td>-0.055</td>
</tr>
<tr>
<td></td>
<td>(0.95)</td>
<td>(-0.66)</td>
<td>(2.76)</td>
<td>(0.98)</td>
<td>(1.75)</td>
</tr>
<tr>
<td>STD of real</td>
<td>-0.007</td>
<td>0.028</td>
<td>-0.011</td>
<td>-0.115</td>
<td>-0.335</td>
</tr>
<tr>
<td>exchange rates</td>
<td>(-0.25)</td>
<td>(0.74)</td>
<td>(-0.26)</td>
<td>(-2.20)</td>
<td>(-4.60)</td>
</tr>
<tr>
<td>SKEW of real</td>
<td>-0.034</td>
<td>-0.008</td>
<td>-0.058</td>
<td>-0.076</td>
<td>-0.163</td>
</tr>
<tr>
<td>exchange rates</td>
<td>(-1.14)</td>
<td>(-0.25)</td>
<td>(-2.08)</td>
<td>(-1.86)</td>
<td>(-2.16)</td>
</tr>
<tr>
<td>Average income</td>
<td>0.389</td>
<td>0.974</td>
<td>0.088</td>
<td>0.164</td>
<td>-0.154</td>
</tr>
<tr>
<td>growth rates</td>
<td>(1.37)</td>
<td>(3.07)</td>
<td>(0.22)</td>
<td>(0.34)</td>
<td>(-0.22)</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.034</td>
<td>0.134</td>
<td>0.021</td>
<td>0.074</td>
<td>0.188</td>
</tr>
</tbody>
</table>

Notes: Ordinary Least Squares (OLS) estimator with heteroskedastic consistent covariance matrix (White 1980) used to calculate standard deviation. * t-ratios are in parenthesis; a, b, and c denote significant at the 1, 5, and 10 percent level.

Table 4.5: Estimation results with alternative measures (sample size=90).

4.2.3.1. Non-EMS Sub-sample

As before, inter-EMS trade was omitted from the sample. The following regression model is estimated with the sub-sample:

(4.5) \[ \Delta \ln q_{yt}^k = \beta_0^k + \beta_1^k \sigma_{yt}^d + \beta_2^k \text{skew}_{yt}^d + \beta_3^k \Delta \ln y_{yt} + \beta_4^k \text{EU} + \epsilon_{yt}^k. \]

The estimation results, reported in Table 4.6, are similar to those for the whole sample so that we have the same economic implication. As a whole, the alternative
normalization does not change the basic findings from the previously used measure, while statistical power of the model decreases significantly. Although recent empirical evidence has indicated mean reverting behavior of real exchange rates, the low statistical power of the alternative measure indicates that the \textit{ex-post} realization of real exchange rates might not be perfectly mean reverting during the sample period. So, average real exchange rates also have useful information for explaining cross-sectional differences of export growth rates among sample countries.

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Machinery</th>
<th>Chemical</th>
<th>Manufacturing</th>
<th>Agriculture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-0.007</td>
<td>-0.025(^{c})</td>
<td>0.020</td>
<td>-0.002</td>
<td>0.018</td>
</tr>
<tr>
<td></td>
<td>(-0.62)</td>
<td>(-1.94)</td>
<td>(1.44)</td>
<td>(-0.09)</td>
<td>(0.60)</td>
</tr>
<tr>
<td>STD of real exchange rates</td>
<td>-0.080</td>
<td>0.003</td>
<td>-0.143(^{c})</td>
<td>-0.309(^{a})</td>
<td>-0.362(^{b})</td>
</tr>
<tr>
<td></td>
<td>(-1.44)</td>
<td>(0.04)</td>
<td>(-1.67)</td>
<td>(-3.46)</td>
<td>(-2.33)</td>
</tr>
<tr>
<td>SKEW of real exchange rates</td>
<td>-0.048(^{c})</td>
<td>-0.031</td>
<td>-0.068(^{b})</td>
<td>-0.087(^{b})</td>
<td>-0.212(^{b})</td>
</tr>
<tr>
<td></td>
<td>(-1.70)</td>
<td>(-0.88)</td>
<td>(-2.12)</td>
<td>(-2.12)</td>
<td>(-2.39)</td>
</tr>
<tr>
<td>Average income growth rates</td>
<td>0.991(^{a})</td>
<td>1.351(^{a})</td>
<td>0.984(^{b})</td>
<td>1.271(^{b})</td>
<td>0.579</td>
</tr>
<tr>
<td></td>
<td>(3.15)</td>
<td>(3.39)</td>
<td>(2.13)</td>
<td>(2.60)</td>
<td>(0.67)</td>
</tr>
<tr>
<td>EU</td>
<td>0.027(^{a})</td>
<td>0.026(^{a})</td>
<td>0.028(^{a})</td>
<td>0.031(^{a})</td>
<td>0.051(^{a})</td>
</tr>
<tr>
<td></td>
<td>(7.39)</td>
<td>(5.77)</td>
<td>(4.54)</td>
<td>(5.12)</td>
<td>(4.94)</td>
</tr>
<tr>
<td>(R^{2})</td>
<td>0.306</td>
<td>0.270</td>
<td>0.227</td>
<td>0.314</td>
<td>0.266</td>
</tr>
</tbody>
</table>

\textit{Notes:} Ordinary Least Squares (OLS) estimator with heteroskedastic consistent covariance matrix (White 1980) used to calculate standard deviation. \(t\)-ratios are in parenthesis; \(a\), \(b\), and \(c\) denote significant at the 1, 5, and 10 percent level.

Table 4.6: Estimation results with alternative measures: non-EMS case (sample size=70).
4.3. Panel Data Approach\textsuperscript{15}

Although the choice of a cross-sectional approach is natural for examining the issue, there are two potential disadvantages of using a cross-sectional approach. First, by averaging the data \textit{a priori}, all the time-series information in the data is simply eliminated. Second, loss of observations from averaging the data could possibly have introduced small-sample bias. For example, the time-series movement of real exchange rates is a good approximation of the time-series movement of misalignment as discussed before. Including the average real exchange rate into the cross-sectional model, we can estimate a long run relationship between variables. However, by eliminating their time-series information \textit{a priori}, we cannot estimate any short- or medium-run relationship between variables. Therefore, maximizing data usage and properly examining the main issue of the paper is an interesting subject.

In this section, in order to achieve both goals simultaneously, two different panel econometric procedures are employed. The basic idea of the two-step methods used in this section is simple. At the first stage of estimation, the time-series relationship between real exchange rate movement and export growth rates is estimated by using a selected panel data analysis. At the second stage of the estimation, their remaining cross-sectional relationships will be examined by a cross-sectional approach.

The following regression model will be used as a basic empirical specification.

\begin{equation}
\Delta \ln q_{yt} = \alpha_0 + \alpha_1 r_{yt} + \alpha_2 \Delta \ln y_{yt} + \alpha_3 \sigma_{yt} + \alpha_4 \text{skew}_{yt} + \epsilon_{yt}
\end{equation}

\textsuperscript{15} Detailed discussion about the panel econometrics used in this section is presented in an appendix.
The important point here is that now there are time-subscripts on the dependent and some of the independent variables. However, the second and third moments of the real exchange rate distribution are still treated as time-invariant variables. Consequently, our empirical model contains two variables moving both with the time and cross-sectional dimensions, and two variables that move only in a cross-sectional dimension. Finally, two different panel estimation methods are based on two different data generating process (DGP) of the time-variant variables.

4.3.1. Hausman and Taylor Estimator

The first panel estimation method used in this section was introduced by Hausman and Taylor (1981). The estimation method is based on the following DGP.

\[
\Delta \ln q_{it}^k = \alpha_{0it}^k + \alpha_i^k r_{it} + \alpha_y^k \Delta \ln y_{it} + \alpha_{y}^k \delta_{it} + \alpha_{skew}^k skew_{it} + \varepsilon_{it}^k
\]

where \( \varepsilon_{it}^k \) is assume to be distributed mean zero and common variance \( \sigma_{\varepsilon}^2 \), and \( \alpha_{0it}^k \) is assumed to be fixed rather than random variables. The only difference between equation (4.6) and (4.7) is now we assume that the constant terms are different in each cross-sectional unit. In an economic sense, this restriction implies that there are cross-country specific latent effects such as distance between countries, which are not captured by the regression model. The idea behind the two-step is simple. At the first stage of the regression, we use the 'within' estimator with transformed data, which is an unbiased and consistent estimator if the above DGP is true. However, by transforming the data, all the time-invariant cross-country latent effects will be eliminated. Therefore, for the second stage of estimation, we construct a latent variable based on the
unbiased and consistent estimates from the first stage regression. At the second stage of estimation, by using the cross-sectional approach, we can easily estimate the coefficients of the time-invariant variables. More detailed discussion about the estimation procedure is presented in the appendix.

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Machinery</th>
<th>Chemical</th>
<th>Manufacturing</th>
<th>Agriculture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real exchange rates</td>
<td>-0.275a</td>
<td>-0.273a</td>
<td>-0.191a</td>
<td>-0.344a</td>
<td>-0.322a</td>
</tr>
<tr>
<td></td>
<td>(-14.92)</td>
<td>(-10.97)</td>
<td>(-5.79)</td>
<td>(-11.12)</td>
<td>(-10.59)</td>
</tr>
<tr>
<td>Income growth rates</td>
<td>1.429a</td>
<td>1.214a</td>
<td>1.245a</td>
<td>1.953a</td>
<td>0.279b</td>
</tr>
<tr>
<td></td>
<td>(18.70)</td>
<td>(11.79)</td>
<td>(9.09)</td>
<td>(15.25)</td>
<td>(2.21)</td>
</tr>
<tr>
<td>STD of real exchange rates</td>
<td>-0.075</td>
<td>0.013</td>
<td>-0.079</td>
<td>-0.230b</td>
<td>-0.359a</td>
</tr>
<tr>
<td></td>
<td>(-0.84)</td>
<td>(0.15)</td>
<td>(-1.04)</td>
<td>(-2.13)</td>
<td>(-3.55)</td>
</tr>
<tr>
<td>SKEW of real exchange rates</td>
<td>-0.075</td>
<td>-0.048</td>
<td>-0.086</td>
<td>-0.127</td>
<td>-0.210b</td>
</tr>
<tr>
<td></td>
<td>(-0.83)</td>
<td>(-0.56)</td>
<td>(-1.12)</td>
<td>(-1.16)</td>
<td>(-2.05)</td>
</tr>
<tr>
<td>Constant</td>
<td>1.241a</td>
<td>1.239a</td>
<td>0.880a</td>
<td>1.539a</td>
<td>1.522a</td>
</tr>
<tr>
<td></td>
<td>(92.5)</td>
<td>(97.6)</td>
<td>(77.3)</td>
<td>(94.8)</td>
<td>(100.0)</td>
</tr>
</tbody>
</table>

Notes: t-ratios are in parenthesis; a and b denote significant at the 1 and 5 percent level.

Table 4.7: Export growth and real exchange rate variability (Hausman and Taylor estimator, sample size=1980).

The estimation results are reported in Table 4.7, where the estimated coefficients for the first two variables are from the first-stage regression, and the remaining coefficients are from the second-stage regression. It is important to note that because the estimated coefficients for the constant come from the second-stage regression, they contain no economic meaning. Compared to the cross-sectional analysis, no
A statistically significant relationship is found between long-run real exchange rate variability and export growth rates in the case of the total, machinery, and chemical sectors. In the case of the manufacturing and agriculture sectors, however, this relationship remains negative and statistically significant. In the case of skewness of the real exchange rate distribution, the negative effect is statistically significant at the 5 percent level only in the case of the agriculture sector.

The estimated coefficients on the real exchange rate measure have the expected negative sign, but they are higher than those of the cross-sectional regression. A possible explanation for this is that in the short- or medium-run, annual movements of export growth rates more sensitively decrease (increase) in response to unfavorable (favorable) real exchange rate movements. In the long-run, however, as a result of mean reversion in real exchange rates, the impact of the real exchange movement on export growth rates will be less than in the medium-run. In other words, exchange rate neutrality approximately holds in the long run.

Finally, in the case of income growth rates, the estimated coefficients all have the expected positive sign, and are statistically significant at the 1 percent level except the agriculture sector which is significant at the 5 percent level. In the case of the agriculture sector, the coefficient implies that a 1 percent increase in income growth rates of two trading partners is associated with only a 0.28 percent increase in trade growth rates among the sample countries, compared to increases in trade growth rates of 1.43, 1.21, 1.26, and 1.95 for the total, machinery, chemical and manufacturing sectors respectively. This result could tell us that, during the post-Bretton Woods era,
agricultural trade integration among sample countries is much lower than any other sector considered in the present study, which is what we would expect a priori.

4.3.2. Random Coefficient Model (RCM) Approach

The second line of econometric methods is under the assumption of different constant and slope coefficients across each cross sectional unit. The estimation procedures suggested by Swamy (1970), Hsiao (1986), Pesaran and Smith (1995), and Maddala et al. (1997) are all based on this assumption. The estimation model under the assumption of heterogeneity of all coefficients becomes:

\[ \Delta \ln q_{ijt} = \alpha_{0jt} + \alpha_{1jt}^k r_{jt} + \alpha_{2jt}^k \Delta \ln y_{it} y_{jt} + \alpha_{3jt}^k \delta_{jt} + \alpha_{4jt}^k \rho_{jt} + \alpha_{5jt}^k s_{jt} \]

For an empirical study with time-invariant variables, there is a difficulty in using these random coefficient model (RCM) specifications. The difficulty comes from the fact that all the estimation procedures in RCM specification are based on separate regression results of each cross-section unit. If the main objective of the study is estimating the effect of the time-invariant variables, RCM estimators can not be applied due to perfect collinearity as previously mentioned. According to my knowledge, there is still no particular estimation procedure to estimate time-invariant variables under RCM specification. In this section, a modified version of the Swamy-Hsiao estimator is used to obtain coefficients on the time-invariant variables under RCM specification. The basic idea of this procedure is similar to that of Hausman and Taylor (1981) and detailed discussion of the estimation procedure is presented in the appendix.

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16 Detailed assumptions about the underlying DGP in this model are described in the appendix.
As a whole, the estimation results presented in Table 4.8 are similar to those of the HT estimator. No statistically significant relationship is found between long-term real exchange rate variability and export growth rates in the case of the total, machinery, and chemical sectors.

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Machinery</th>
<th>Chemical</th>
<th>Manufacturing</th>
<th>Agriculture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real exchange rates</td>
<td>-0.254(^a)</td>
<td>-0.221(^a)</td>
<td>-0.166(^a)</td>
<td>-0.306(^a)</td>
<td>-0.312(^a)</td>
</tr>
<tr>
<td></td>
<td>(-8.09)</td>
<td>(-6.13)</td>
<td>(-3.14)</td>
<td>(-6.12)</td>
<td>(-6.80)</td>
</tr>
<tr>
<td>Average income growth rates</td>
<td>1.428(^a)</td>
<td>1.327(^a)</td>
<td>1.253(^a)</td>
<td>1.981(^a)</td>
<td>0.302</td>
</tr>
<tr>
<td></td>
<td>(12.89)</td>
<td>(9.50)</td>
<td>(6.59)</td>
<td>(10.76)</td>
<td>(1.65)</td>
</tr>
<tr>
<td>STD of real exchange rates</td>
<td>-0.075</td>
<td>0.006</td>
<td>-0.079</td>
<td>-0.232(^b)</td>
<td>-0.360(^a)</td>
</tr>
<tr>
<td></td>
<td>(-0.91)</td>
<td>(0.08)</td>
<td>(-1.14)</td>
<td>(-2.39)</td>
<td>(-3.65)</td>
</tr>
<tr>
<td>SKEW of real exchange rates</td>
<td>-0.072</td>
<td>-0.040(^b)</td>
<td>-0.082</td>
<td>-0.121</td>
<td>-0.209(^b)</td>
</tr>
<tr>
<td></td>
<td>(-0.85)</td>
<td>(-0.58)</td>
<td>(-1.17)</td>
<td>(-1.23)</td>
<td>(-2.08)</td>
</tr>
<tr>
<td>Constant</td>
<td>1.144(^a)</td>
<td>1.00(^a)</td>
<td>0.766(^a)</td>
<td>1.364(^a)</td>
<td>1.473(^a)</td>
</tr>
<tr>
<td></td>
<td>(92.1)</td>
<td>(96.1)</td>
<td>(73.67)</td>
<td>(93.6)</td>
<td>(99.36)</td>
</tr>
</tbody>
</table>

Notes: t-ratios are in parenthesis; \(^a\) and \(^b\) denote significant at the 1 and 5 percent level.

Table 4.8: Export growth and real exchange rate variability (The Modified Swamy-Hsiao estimator, sample size=1980).

In the case of the manufacturing and agriculture sectors, however, this relationship remains negative and statistically significant. In the case of skewness of the real exchange rate distribution, the negative effect is statistically significant at the 5 percent level only in the case of the agriculture sector. The estimated coefficients on the real exchange rate measure have the expected negative sign, but they are higher than those of cross-sectional regression are. Finally, in the case of income growth rates, the
estimated coefficients all have the expected positive sign, and are statistically
significant at the 1 percent level except agriculture sector.

4.4. Discussion

In this chapter, I examined empirically some hypotheses derived in the previous
chapter. Using a cross-sectional approach, the following conclusions are reached. First,
the long-term variability of real exchange rates has been large enough to cause real
impact on international commodity trade flows especially in the agricultural sector. In
the cases of relatively large scale industries such as the chemical and machinery sectors,
long-term real exchange rate variability has not been large enough to cause any
explicitly negative impact on trade growth rates among sample countries. Second, as
suggested by the hysteresis model, one time huge and unfavorable exchange rate shocks
have caused more negative impacts on export growth rates than small but favorable
exchange rate shocks in the cases of the manufacturing and agricultural sectors.
However, in the case of large-scale industries, we cannot observe any explicit
relationship between variables as indicated in the previous chapter. Considering the
first moment of real exchange rate distribution, we found that agriculture exports have
reacted around four times more sensitively than total exports.

The estimation results with panel data analysis are weaker than that of the cross-
sectional approach. The potential reason for this weak evidence might be due to the
time-series movement of real exchange rates included in the panel analysis. Simply,
most of the effect of real exchange rate movement has been captured by the time-series
movement of the variable at the first stage of the regression. Therefore, the remaining
effect of the cross-sectional variation of the second and third moments of the real
exchange rate distribution becomes weaker. However, even in a panel data analysis, I
found the signs of the second and third moments of the real exchange rate distribution
have been negatively associated with export growth rates in the agricultural sector,
which supports the main hypothesis of the study.
CHAPTER 5

REAL EXCHANGE RATE VOLATILITY

High short-term volatility\(^1\) of exchange rates since the floating system has been another important issue connected with international trade. Casual empirical observation shows that in the short-term (i.e. monthly, quarterly, and yearly), exchange rate movements among developed countries have become much more volatile since 1973 (Hasan and Wallace, 1996). For instance, monthly volatility of real exchange rates between Germany and the US under the floating system is around fifteen times more than that under the fixed system. Although economists have worried about huge increases in short-term volatility under the floating system, a majority of empirical studies have failed to reach an unambiguous conclusion of the existence of its negative real impact on trade (Obstfeld 1995)\(^2\). Reflecting the wider literature, empirical research, relating to short-term exchange rate volatility and agricultural trade flows, has

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\(^1\) Although we use annual volatility of real exchange for the empirical study, we will call it 'short-term volatility' in order to distinguish it from 'long-term variability' or 'misalignment'.

\(^2\) For example, Cushman (1983, 1988), Kenen and Rodrick (1986), and Chowdhury (1993) found a negative effect of exchange rate volatility on trade while Klein (1990) and Asseery and Peel (1991) found a positive effect.
also given ambiguous conclusions. For example, Pick (1990) found that exchange rate risk had no effect on US trade flows with other developed countries, though it did have a negative effect on US exports to developing countries. In contrast, Maskus (1986) and Klein (1990) found that short-run real exchange rate volatility negatively affected US agricultural exports compared to other sectors.

On the other hand, however, it is also true that many economists believe that decreasing short-term volatility of exchange rates is one of the important motivations for the formation of a monetary union among European countries (i.e., Frankel, 1996). Empirical evidence suggests that the member countries of EMS have faced relatively small exchange rate volatility since 1979 (Fountas and Aristotelous, 1999; Rose, 2000). If short-term volatility has not caused any serious real impact on international commodity trade flows, why have European countries continually tried to achieve their goal of less volatile exchange rates in spite of losing some degree of monetary independence? Does the empirical evidence simply show over-reaction of European countries to an unimportant noisy factor? Or, have most of the empirical studies, which depend on univariate time-series data, failed to include important aspects (dimensions) of short-term volatility in their empirical work? I believe that there are two important issues which can not be examined using univariate time-series data.

The first comes from the question concerning what are the important factors determining short-term volatility of the exchange rate between two countries\(^3\). In fact,

\(^3\) In theory, there have been many different explanations for the sources of short-term volatility under the assumptions of a given degree of policy coordination. However, as McKinnon (1988) indicates, it might be true that the most important factor to determine the magnitude of short-term volatility is the degree of monetary policy coordination between countries. More detailed discussion about the determinant of
one of the fundamental determinants of short-term volatility in exchange rates might be the degree of monetary coordination. For instance, once monetary policy coordination between countries settles down, short-term volatility of exchange rates has shown a relatively similar pattern under the same degree of coordination. On the other hand, if countries employ different degrees of policy coordination, the magnitude of short-term volatility is dramatically different under the two different monetary regimes. Therefore, cross-country differences in short-term volatility due to different degrees of policy coordination might be an important dimensional movement of short-term volatility. However, the usual time-series approach cannot be used to examine this important issue.

Another reason, which emphasizes the importance of cross-country differences in short-term exchange rate volatility, is suggested by Cushman (1986), and Wolak and Kolstad (1991). Cushman indicates that the issue of short-term volatility should be understood in a relative sense. For example, even when exchange rate volatility between two countries increases compared to the last period, it does not mean there is a negative effect on bilateral trade. If this volatility between two particular countries is relatively less than that with respect to all other trading partners, we could even find a positive correlation instead. Wolak and Kolstad (1991) also emphasize the importance of relative import price uncertainty on the choice problem of the importer. They show

short-term volatility (market microstructure approach) under the free floating system is presented in Frankel and Rose (1995).

For instance, Mussa (1995) investigates monthly volatility of bilateral real exchanges among three major currencies (US dollar, Deutsche Mark, and Japanese Yen) during the periods of 1973-1978, 1979-1986, and 1987-1995. He found that there has been no meaningful change in the degree of monthly real exchange rate volatility in each period.
import firms trade off expected input cost against its volatility in selecting the optimal input supplier mix. Consequently, relative import price uncertainty has an important role in the choice problem for importers if importing goods are homogeneous. As a mirror image, it also implies that relative import price uncertainty should have an important role in explaining relative import volume. As Wolak and Kolstad mentioned in their paper, one of the most important factors to cause relative import price variability should be exchange rate volatility. Therefore, without considering relative short-term exchange rate volatility across trading partners, time-series studies have investigated only a one-dimensional movement of short-term volatility.

Although cross-country differences in exchange rate volatility is an important issue in connection with international commodity trade, empirical studies examining this issue are sparse. The only exception is Rose (2000). Using a gravity type model with a large cross-sectional data set, he examined this issue empirically and found weak evidence of a negative linkage between exchange rate volatility and the total trade growth rate. However, according to the hypothesis of Wolak and Kolstad, the impact could be more serious for sectors producing relatively homogeneous goods than the aggregate level trade.

In this chapter, I examine the relationship between short-term exchange risk and sectoral trade growth rates concentrating on their cross-country differences. Two different approaches are employed. The first one is a cross-sectional approach followed by Rose, which gives us a long-run relationship between variables. The second one is a
time fixed effect model, which give us their medium-run relationship\(^5\). After that, I also examine whether time-series variations in short-term exchange rate uncertainty have a real impact on agricultural trade flows because this issue is still important in the relevant literature. With these comparisons, we might get some sense of why short-term exchange rate volatility is still an important issue for agricultural trade although the time-series evidence is weak. Finally, by investigating a cross-sectional linkage between short-term exchange rate risk and long-term variability, I will show why both issues should not be treated separately.

5.1. A Proxy Variable of Exchange Rate Uncertainty

In the relevant literature, the most popularly used method to obtain a proxy variable of time varying exchange rate uncertainty is the moving sample standard deviation of the growth rate of the real exchange rate. For instance, Kenen and Rodrik (1986), Koray and Lastrapes (1989), and Chowdhury (1993) used this measure for their empirical studies. In the present study, this method is also used for consistency with other previous studies. \(\tilde{\nu}_{q_t}^r\) is considered as a proxy variable of exchange rate uncertainty due to annual changes of real exchange rates\(^6\). The following formula was used:

---

\(^5\) In general, economists interpret the estimated coefficients from a cross-sectional regression as representing a long run relationship, while those from a panel data analysis represent a medium run relationship between variables.

\(^6\) In fact, it is a time-varying measure of real exchange rate volatility rather than exchange rate uncertainty. Since there is no unique way to measure exchange rate uncertainty, however, economists have generally used some measure obtained from past and current exchange rate volatility as a proxy variable for the future exchange rate uncertainty. In spite of this weakness, the measure used in the present study has been popularly used in the relevant literature. See Akhtar and Hilton (1984) or Pagan and Ulla (1988) for a discussion on different proxy measures for exchange rate uncertainty.
(5.1) 
\[ \hat{\sigma}_{ij}^2 = \left( \frac{1}{m} \sum_{k=0}^{m} (\Delta \ln R_{ij-k})^2 \right)^{1/2}, \]

where \( R_{ij} \) is the real exchange rate between exporting country \( i \) and importing country \( j \) at year \( t \) as defined earlier, \( m \) is the order or lag length of the moving average, and \( \Delta \) is the usual first difference operator. I choose \( m \) equal to \( \text{three} \) for empirical study in this section.

There are some criticisms of this measure due to the arbitrary choice of lag length \( m \) (\textit{i.e.}, Pagan and Ulla, 1988). A popularly used alternative would be to estimate the conditional variance of the exchange rate series using autoregressive conditional on heteroskedasticity (ARCH) type specifications suggested by Engle (1982). Although such a parametric approach can be successful in modeling high frequency financial data series, annual exchange rate data are too low a frequency for such an approach to yield useful results. Carruth \textit{et al.} (1998) survey different specifications to obtain a proxy variable of risk, and show that they make very little difference to the numerical results. In fact, their result is not so surprising because the moving standard deviation is the most basic nonparametric smoothing method. If the ARCH-type specification is correct, the pattern of the proxy variable is similar to our measure in a time-series sense. The only difference might be their smoothness. Different choices of lag length also affects only smoothness of the measure\(^7\). Although the cross-validation (CV) criterion is usually used to choose optimal lag-length (bandwidth), without enough time-series data, an arbitrary choice of lag length is inevitable. In the cross-sectional approach, 

\(^7\) More detailed discussion of the variety of nonparametric smoothing methods can be found in Hastie and Tibshirani (1990).
however, different smoothness of the exchange rate uncertainty measure would not affect the results of the final model, because the important point, in this case, is not the smoothness of the measure in a time-series sense but their average magnitude during the sample period.

5.2. A Cross-Sectional Approach

In this section, I present some empirical results which examine the short-term volatility issue using the cross-sectional approach followed by Rose. The empirical model used in this section is similar to that used for examining the misalignment issue. I simply replace the misalignment measure \( \hat{\sigma}_y \) with the sample average of the exchange rate uncertainty measure \( \bar{\tilde{\nu}}_y \) over time for each country pair. Therefore, the main empirical question in this section is whether countries that have faced higher short-term exchange rate uncertainty on average have also faced lower trade growth rates on average. The estimated coefficients should be interpreted as a long run relationship between variables as mentioned before. The following regression model is estimated:

\[
(5.2) \quad \Delta \ln \sigma^k_{yt} = \alpha_0^k + \alpha_1^k r_{yt} + \alpha_2^k \bar{\tilde{\nu}}_{yt} + \alpha_3^k \Delta \ln y_{it} y_{jt} + \alpha_4^k \text{skew}_{yt} + \epsilon^k,
\]

where all the variables are defined earlier.

---

8 Because there is a strong positive correlation between short-term exchange uncertainty and long-term variability measures, I do not include both variables in the regression model. A discussion about this strong correlation between variables will be presented later in this chapter.

9 The choice of lag length to obtain proxy variable of exchange uncertainty is three for the regression. In fact, estimations have also been performed using two different lag lengths, two and four. The estimation results suggest that the conclusion appears to be robust to different choice of the lag lengths.
Table 5.1: Relationship between average export growth and average exchange rate uncertainty (sample size=90).

The estimation results for the whole sample are shown in Table 5.1 and these are generally similar to those for the case of misalignment. In the case of average real exchange rates, we can reject the null hypothesis of no relationship at the 1 percent level for all sectors, and the signs of the estimated coefficients are negative as expected. As before, the response of trade growth rates to real exchange rates is highest for agriculture among the sectors considered here. In the case of skewness of the real exchange rate distribution, the estimated coefficients are statistically significant in the case of chemical, manufacturing, and agriculture sectors. In the case of the average
growth rate in real income, the estimated coefficients are statistically significant in the total and machinery sectors, which are positive as we expected.

The estimated coefficients on the exchange rate uncertainty measure are not statistically significant at the 10 percent level in the case of machinery and chemical sector trade. The estimated $t$-statistics on the variable are 0.08 and $-0.62$ respectively, so that we cannot reject the null hypothesis of no relationship at the 10 percent level. In contrast, they are statistically significant, and negatively related to export growth rates in the case of the manufacturing and agriculture sectors. The estimated $t$-ratios are $-2.68$ for the manufacturing and $-5.02$ for the agriculture sectors respectively, which are significant at the 1 percent level. In the case of total trade, the estimated coefficient is $-0.082$, which is statistically significant only at the 10 percent level. However, the negative linkage is smaller in an economic sense and weaker in a statistical sense than those of manufacturing and agricultural sectors.

The estimated coefficients imply that a one-unit increase in the measure of exchange rate uncertainty is associated with a 8.2 percent reduction in total trade growth, a 22.9 percent reduction in trade growth in the manufacturing sector, and a 56.1 percent reduction in trade growth in the agricultural sector. Compared to the other exporting sectors, we can easily see that the sensitivity of the growth in agricultural sector trade in response to exchange rate uncertainty is much larger in the long run. Although these figures are high at first glance, the calculated average exchange rate uncertainty measure is only 0.08 on the sample average. Therefore, the associated reduction of trade growth among sample countries is about 0.7 percent in the case of
total, about 1.8 percent in the manufacturing sector, and about 4.5 percent in the agricultural sector. These results are also very similar to those of the previous chapter, and the potential reason for this similarity will be discussed later in this chapter.

5.2.1. Non-EMS Sub-sample

As before, inter-EMS trade was omitted from the sample and the following model was estimated with this sub-sample.

\[(5.3) \quad \Delta \ln q_{it}^k = \alpha_0^k + \alpha_1^k \bar{r}_{it} + \alpha_2^k \bar{\nu}_r + \alpha_3^k \Delta \ln y_{it}y_{jt} + \alpha_4^k \text{skew}_{ij} + \alpha_5^k E_U + \epsilon^k\]

The estimation results, reported in Table 5.2, are similar to those for the whole sample. An important difference is that we can more strongly reject the null of no relationship in the case of total trade. In the case of agriculture and manufacturing sector trade, the estimated coefficients on the exchange rate uncertainty measure are negative and statistically significant. The estimated \(t\)-statistics are \(-3.74\) for manufacturing and \(-2.12\) for the agriculture sector respectively, so that we can reject the null hypothesis of no relationship at the 1 and 5 percent level. In the case of the machinery and chemical sectors, we cannot find any statistically significant relationship between variables. As a whole, using cross-sectional analysis, two important findings are obtained. First, I found cross-country differences in short-term exchange rate uncertainty have been negatively associated with total trade growth rates in the long run, which is a similar result to that of Rose. Second, there was some evidence of different sectoral impacts of annual real exchange rate volatility as suggested by Wolak and Kolstad. For instance, short-term exchange rate uncertainty is more negatively
associated with sectors producing relatively homogeneous products than sectors producing relatively differentiated products, which is what we expected a priori.

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Machinery</th>
<th>Chemical</th>
<th>Manufacturing</th>
<th>Agriculture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.134a</td>
<td>0.186a</td>
<td>0.070</td>
<td>0.289a</td>
<td>0.606a</td>
</tr>
<tr>
<td></td>
<td>(2.92)</td>
<td>(3.68)</td>
<td>(1.03)</td>
<td>(4.48)</td>
<td>(5.29)</td>
</tr>
<tr>
<td>Average real exchange rates</td>
<td>-0.029a</td>
<td>-0.045a</td>
<td>-0.009</td>
<td>-0.059a</td>
<td>-0.124a</td>
</tr>
<tr>
<td></td>
<td>(-3.00)</td>
<td>(-3.65)</td>
<td>(-0.68)</td>
<td>(-4.57)</td>
<td>(-5.24)</td>
</tr>
<tr>
<td>Average exchange rate uncertainty</td>
<td>-0.219a</td>
<td>-0.051</td>
<td>-0.187</td>
<td>-0.417a</td>
<td>-0.415b</td>
</tr>
<tr>
<td></td>
<td>(-4.40)</td>
<td>(0.67)</td>
<td>(-1.57)</td>
<td>(-3.74)</td>
<td>(-2.12)</td>
</tr>
<tr>
<td>SKEW of real exchange rates</td>
<td>-0.056b</td>
<td>-0.044</td>
<td>-0.071b</td>
<td>-0.105b</td>
<td>-0.248a</td>
</tr>
<tr>
<td></td>
<td>(-2.08)</td>
<td>(-0.31)</td>
<td>(-2.22)</td>
<td>(-2.76)</td>
<td>(-2.92)</td>
</tr>
<tr>
<td>Average income growth rates</td>
<td>1.001a</td>
<td>1.437b</td>
<td>0.701c</td>
<td>0.677</td>
<td>-0.222</td>
</tr>
<tr>
<td></td>
<td>(3.95)</td>
<td>(5.57)</td>
<td>(1.91)</td>
<td>(1.43)</td>
<td>(-0.37)</td>
</tr>
<tr>
<td>EU</td>
<td>0.024a</td>
<td>0.025a</td>
<td>0.027a</td>
<td>0.029a</td>
<td>0.051a</td>
</tr>
<tr>
<td></td>
<td>(7.31)</td>
<td>(5.90)</td>
<td>(4.79)</td>
<td>(5.89)</td>
<td>(4.35)</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.443</td>
<td>0.430</td>
<td>0.225</td>
<td>0.456</td>
<td>0.459</td>
</tr>
</tbody>
</table>

Notes: Ordinary Least Squares (OLS) estimator with heteroskedastic consistent covariance matrix (White 1980) used to calculate standard deviation. $t$-ratios are in parenthesis; a, b, and c denote significant at the 1, 5, and 10 percent level.

Table 5.2: Relationship between average export growth and average exchange rate uncertainty: non-EMS case (sample size=70).

It might be true that international commodity traders can hedge their time-varying future exchange uncertainty using a variety of financial tools in foreign exchange markets. However, it might also be true that hedging given cross-country differences in exchange rate uncertainty might not be so easy using those financial tools. For instance,
if an importer faces two foreign suppliers, and the exchange rate of one of them is clearly more unstable than another during some period, it is a natural choice for the importer to import more from the more stable supplier. As Wolak and Kolstad indicate, if traded goods are almost perfectly substitutable, the negative effect could be substantial. This might be a reason why I can easily find a substantial negative relationship between variables in the case of sectors producing relatively homogenous goods.

5.3. Panel Data Analysis I

Using a cross-sectional approach, I focused on the long-run relationship between variables. In this section, a medium-run relationship between variables will be examined focusing on cross-sectional variation of the data. The way I concentrated on cross-sectional variations of the data, as well as using the whole sample, is by employing the following time fixed effect model:

\[
\Delta \ln q_{yt} = \theta_t^k + \alpha_t^k r_{yt} + \alpha_2^t \Delta \ln y_{yt} + \alpha_3^t \hat{v}_{yt} + \epsilon_{yt}^k
\]

\(\theta_t^k\) is time-series fixed effect, which is expected to capture common time-series shocks affecting sample countries simultaneously, for example, the effects of the oil shock, and the effect of faster economic growth of developing countries. Unlike the previously used cross-country fixed effect model ('within' estimator), the estimated coefficients

---

10 As a whole, the results in this section are quite similar to those of Maskus (1986). He investigated the different sectoral effects of exchange rate risk concentrating on US exports during the period of 1974–1984. He found that the negative impact was large in the case of the agriculture and manufacturing sectors, while in the case of the chemical, machinery, and transport equipment sectors, the effect was relatively small.
under this assumption strongly depend on cross-sectional variation of the data because
the variable $\theta_i^k$ captures the common time-series variation of the data. Table 5.3
presents the estimation results, which are much weaker than those from the cross-
sectional approach although the signs are all negative.

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Machinery</th>
<th>Chemical</th>
<th>Manufacturing</th>
<th>Agriculture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real exchange rates</td>
<td>-0.126*</td>
<td>-0.134*</td>
<td>-0.081*</td>
<td>-0.171*</td>
<td>-0.200*</td>
</tr>
<tr>
<td>(-11.5)</td>
<td>(-8.70)</td>
<td>(-4.35)</td>
<td>(-9.31)</td>
<td>(-10.4)</td>
<td></td>
</tr>
<tr>
<td>Income growth rates</td>
<td>0.840*</td>
<td>0.909*</td>
<td>0.604*</td>
<td>0.716*</td>
<td>0.381*</td>
</tr>
<tr>
<td>(7.96)</td>
<td>(6.11)</td>
<td>(3.37)</td>
<td>(4.04)</td>
<td>(2.05)</td>
<td></td>
</tr>
<tr>
<td>Exchange rate uncertainty</td>
<td>-0.067</td>
<td>-0.071</td>
<td>-0.090</td>
<td>-0.077</td>
<td>-0.395*</td>
</tr>
<tr>
<td>(-1.19)</td>
<td>(-0.89)</td>
<td>(-0.94)</td>
<td>(-0.82)</td>
<td>(-3.97)</td>
<td></td>
</tr>
</tbody>
</table>

Notes: t-ratios are in parenthesis; a and b denote significant at the 1 and 5 percent level.

Table 5.3: Relationship between export growth and exchange rate uncertainty (time
fixed effect model, sample size=1980).

We cannot find any statistically significant relationship between exchange rate
uncertainty and export growth rates in the total, machinery, chemical, and
manufacturing sectors. The estimated $t$-statistics are -1.19, -0.89, -0.94, and -0.82
respectively, which are not statistically significant at the 10 percent level. However, I
found a statistically significant negative relationship between variables in the case of the
agricultural sector. The estimated coefficient is -0.395, which is significant at the 1
percent level. Therefore, in the medium-run, the cross-country differences in exchange

---

11 In practice, I used transformed data for estimation instead of using 22 time dummy variables. Therefore, there is no constant term in the Table 5.3. However, the estimated coefficients are the same in both cases.
rate uncertainty have been negatively associated with trade growth only in the agricultural sector. Finally, the estimated coefficients on other independent variables are similar to those of the previous chapter. All estimated coefficients on the real exchange rate variable and the income growth rate variable are statistically significant and the signs are as expected.

5.4. Panel Data Analysis

In the previous sections, I emphasized cross-sectional variation of the data based on the empirical evidence in this area. However, whether the time-series variations of short-term exchange rate uncertainty are important in explaining trade growth rates is still an important empirical question. Therefore, in this section, I focus on the time-series movements of short-term exchange rate uncertainty. The basic regression model used in this section is as follow:

\[
\Delta \ln q_{yt} = \alpha_0 + \alpha_1 \Delta \ln r_{yt} + \alpha_2 \Delta \ln y_{yt} + \alpha_3 \nu_{yt} + \epsilon_{yt}.
\]

Two panel econometric methods were used to examine the time-series relationship between variables. The first one was the ‘within’ (or cross-sectional fixed effect model) estimator. The second one is a generalized least square (GLS) estimator suggested by Swamy and Hsiao (SH estimator) based on a random coefficient model (RCM) specification. As discussed earlier, both ‘within’ and SH estimators depend for their estimations on time-series variation of the data (Maddala, 1971) so that the results

---

12 See appendix to see a detailed discussion about the panel econometric methods employed in this chapter.
might be interpreted in the time-series sense. Finally, because the regression equation does not contain any time-invariant variables, we do not need to use the two-step method used in the previous chapter, but can directly apply the original methods.

5.4.1. Estimation Results: Within Estimator

Under the assumption of the same slope coefficients but different constant term across cross-sectional units, the estimation model becomes:

\[
\Delta \ln q^k_{yt} = \alpha_{0ij} + \alpha_1^k r_{yt} + \alpha_2^k \Delta \ln y_{it} + \alpha_3^k \tilde{V}_{yt} + \epsilon^k_{yt}
\]

The 'within' estimator is an unbiased and consistent estimator when some of independent variables are correlated with unobservable latent effects under the model specification (5.6) (Mundlack, 1978). Because it ignores all the cross sectional variation of data for estimation, however, it might not be fully efficient if the unobservable latent effect is not correlated with some of the independent variables. In spite of losing some efficiency gain, because our primary objective in this section is to examine the time-series relationship between variables, using the 'within' estimator should be a proper choice.

Table 5.4 reports the estimation results, which are different from those of the cross-sectional approach. Simply, I cannot find any statistically significant relationships between exchange rate uncertainty and export growth rates. The estimated \(t\)-ratios in the agriculture and manufacturing sectors are 0.89 and -0.47, which are too low to reject the null no relationships between variables at the 10 percent level.

---

13 Although regression equation (5.5) is simple, it has been popularly used in time-series analysis. For instance, Pozo (1992) and Chowdhury (1993) used similar specifications for their empirical studies.
Therefore, we can easily reach the conclusion that short-term exchange rate volatility has a neutral effect on international commodity trade if we only consider the time-series movement of the variable. The estimated coefficient on the two other independent variables are similar to those of the previous chapter. All estimated coefficients on the real exchange rate variable and the income growth rate variable are statistically significant and the signs are as expected.

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Machinery</th>
<th>Chemical</th>
<th>Manufacturing</th>
<th>Agriculture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real exchange rates</td>
<td>-0.275a</td>
<td>-0.273a</td>
<td>-0.191a</td>
<td>-0.344a</td>
<td>-0.322a</td>
</tr>
<tr>
<td></td>
<td>(-14.9)</td>
<td>(-10.97)</td>
<td>(-5.79)</td>
<td>(-11.12)</td>
<td>(-10.6)</td>
</tr>
<tr>
<td>Income growth rates</td>
<td>1.428a</td>
<td>1.202a</td>
<td>1.231a</td>
<td>1.965a</td>
<td>0.273b</td>
</tr>
<tr>
<td></td>
<td>(18.6)</td>
<td>(11.61)</td>
<td>(8.93)</td>
<td>(15.26)</td>
<td>(2.15)</td>
</tr>
<tr>
<td>Exchange rate uncertainty</td>
<td>-0.005</td>
<td>-0.121</td>
<td>-0.141</td>
<td>0.121</td>
<td>-0.063</td>
</tr>
<tr>
<td></td>
<td>(-0.06)</td>
<td>(-1.10)</td>
<td>(-0.97)</td>
<td>(0.89)</td>
<td>(-0.47)</td>
</tr>
</tbody>
</table>

Notes: t-ratios are in parenthesis; a and b denote significant at the 1 and 5 percent level.

Table 5.4: Relationship between export growth and exchange rate uncertainty (within estimator, sample size=1980).

5.4.2. Estimation Results: SH Estimator

Next, I report the estimation results when we assume a RCM specification. Under the assumption of heterogeneity of the constant and slope coefficients across cross-sectional units, the estimation model in this case is:

\[
\Delta \ln q_{yt}^k = \alpha_{0y}^k + \alpha_{1y}^k r_{yt} + \alpha_{2y}^k \Delta \ln y_{yt} + \alpha_{3y}^k \hat{\nu}_{yt} + \epsilon_{yt}^k .
\]
The original version of the GLS estimator introduced by Swamy and Hsiao (SH estimator) was employed for estimation. Because the SH estimator is based on separate time-series regression results from each cross-section, it might be better to interpret the results in the time-series sense.

Table 5.5 reports the estimation results, and they are virtually the same as those of the ‘within’ estimator. I do not find any statistically significant relationship between the exchange rate uncertainty measure and export growth rates in all the cases. The estimated t-ratios in agriculture and manufacturing sectors are 0.01 and -0.64 respectively.

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Machinery</th>
<th>Chemical</th>
<th>Manufacturing</th>
<th>Agriculture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real exchange rates</td>
<td>-0.233</td>
<td>-0.187</td>
<td>-0.143</td>
<td>-0.281</td>
<td>-0.298</td>
</tr>
<tr>
<td></td>
<td>(-6.50)</td>
<td>(-4.28)</td>
<td>(-2.50)</td>
<td>(-5.00)</td>
<td>(-5.64)</td>
</tr>
<tr>
<td>Income growth rates</td>
<td>1.450</td>
<td>1.331</td>
<td>1.276</td>
<td>2.007</td>
<td>0.309</td>
</tr>
<tr>
<td></td>
<td>(12.5)</td>
<td>(8.95)</td>
<td>(6.36)</td>
<td>(10.5)</td>
<td>(1.63)</td>
</tr>
<tr>
<td>Exchange rate uncertainty</td>
<td>-0.039</td>
<td>-0.081</td>
<td>-0.051</td>
<td>0.002</td>
<td>-0.130</td>
</tr>
<tr>
<td></td>
<td>(-0.29)</td>
<td>(-0.48)</td>
<td>(-0.27)</td>
<td>(0.01)</td>
<td>(-0.64)</td>
</tr>
<tr>
<td>Constant</td>
<td>1.045</td>
<td>0.851</td>
<td>0.663</td>
<td>1.216</td>
<td>1.377</td>
</tr>
<tr>
<td></td>
<td>(6.28)</td>
<td>(4.20)</td>
<td>(2.48)</td>
<td>(4.72)</td>
<td>(5.67)</td>
</tr>
</tbody>
</table>

*Notes. t-ratios are in parenthesis; a and b denote significant at the 1 and 5 percent level.*

Table 5.5: Relationship between export growth and exchange rate uncertainty (SH estimator, sample size=1980).
As a whole, using panel estimation methods, which mainly depend on time-series information of the data, I do not find any statistically significant relationship between exchange rate uncertainty and trade growth rates among sample countries. Compared to the results of the cross-sectional approach, these results give us a radically different conclusion. However, I believe this conclusion is not so reliable because the results were based only on a one-dimensional movement of short-term exchange rate volatility.

5.5. Cross-Sectional Relationship between Long-term Real Exchange Rate Variability and Short-term Volatility

Using a cross-sectional approach, I found a negative long-run relationship between short-term exchange rate uncertainty and commodity trade flows for some industry sectors. Although these results are consistent with those of Rose, they are also similar to the results in the previous chapter. Why do two seemingly unrelated measures give us such similar results? Is there any strong correlation between two measures? If so, why?

To answer the first question, I will examine the relationship between exchange rate uncertainty and the magnitude of misalignment measures by a cross-sectional approach. Therefore, the empirical question is whether countries that have faced larger misalignment during the sample period have also faced higher exchange rate uncertainty on average. To examine this relationship, the following regression equation is estimated.

\[
\hat{\sigma}_q' = \alpha + \beta \, \bar{V}_{q,t} + \epsilon_q',
\]
where \( \bar{\bar{\psi}}_{yt} \) is a sample average of the exchange rate uncertainty measure \( \bar{\psi}_{yt} \) over time for each country pair \( (\bar{\bar{\psi}}_{yt} = \frac{1}{T} \sum_{t=1}^{T} \bar{\psi}_{yt} ) \). To show that the results are not due to the choice of lag length in equation, four different choices of lag length (one, two, three, and four) are used to obtain short-term exchange rate uncertainty.

Table 5.6 presents the results with two correlation coefficients. The results show that there is a strong positive correlation between the variables. The estimated \( t \)-statistics are more than 15 in all cases so that we can reject the null hypothesis at the 1 percent level. Furthermore, estimated \( R^2 \)'s are also high, around 0.7. Two correlation coefficients also show strong positive correlation between variables. The estimated correlation coefficients are more than 0.8 in all cases.

<table>
<thead>
<tr>
<th></th>
<th>( m = 1 )</th>
<th>( m = 2 )</th>
<th>( m = 3 )</th>
<th>( m = 4 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.023 ( a )</td>
<td>0.020 ( a )</td>
<td>0.020 ( a )</td>
<td>0.020 ( a )</td>
</tr>
<tr>
<td></td>
<td>(3.53)</td>
<td>(3.23)</td>
<td>(3.22)</td>
<td>(3.10)</td>
</tr>
<tr>
<td>Average exchange rate uncertainty</td>
<td>1.711 ( a )</td>
<td>1.551 ( a )</td>
<td>1.482 ( a )</td>
<td>1.467 ( a )</td>
</tr>
<tr>
<td></td>
<td>(15.7)</td>
<td>(17.2)</td>
<td>(17.7)</td>
<td>(17.5)</td>
</tr>
<tr>
<td>( R^2 )</td>
<td>0.689</td>
<td>0.717</td>
<td>0.725</td>
<td>0.723</td>
</tr>
<tr>
<td>Correlation coefficient (Pearson)</td>
<td>0.830</td>
<td>0.847</td>
<td>0.852</td>
<td>0.850</td>
</tr>
<tr>
<td>Correlation coefficient (Spearman)</td>
<td>0.821</td>
<td>0.846</td>
<td>0.854</td>
<td>0.850</td>
</tr>
</tbody>
</table>

Notes: Ordinary Least Squares (OLS) estimator with heteroskedastic consistent covariance matrix (White 1980) used to calculate standard deviation; \( t \)-ratios are in parenthesis; \( a \) denotes significance at the 1 percent level.

Table 5.6: Cross-sectional correlation between two measures (sample size = 90).
Therefore, we can easily conclude that countries that have faced more annual volatility of real exchange rates (exchange rate uncertainty) on average have also faced a larger deviation of nominal exchange rates from PPP during the post-Bretton Woods period. This positive correlation could be a potential reason why two seemingly different measures are similarly associated with the trade growth rate.

However, answering the second question is much more difficult. Why have countries that have faced more annual volatility of real exchange rates (exchange rate uncertainty) also faced larger deviation of nominal exchange rates from PPP during the sample period? As I discussed in the chapter 3, in theory, there is no particular reason that the two measures are correlated with each other. In spite of that, the following story might be of relevance in connection with this empirical phenomenon.

As I mentioned previously, when the floating exchange rate system started, economists generally believed that a new market based system could mitigate misalignment problems, although it might cause more short-term volatility. Therefore, if we believe that the free floating system is the right way to avoid misalignment, countries under the purely free floating system might have enjoyed less misalignment problems although they might have faced higher short-term volatility. On the other hand, it is also well known that some European countries have used a target zone or managed floating exchange rate system since 1979. This target zone system, in fact, has needed strong government intervention in the foreign exchange markets, and more strict international coordination to manage exchange rates. As I mentioned previously, there is a consensus that short-term volatility among EMS countries has been smaller
than that of countries using the free floating system. From the traditional view, unnecessary government intervention of European countries might cause more of an exchange rate misalignment problem, although they have experienced less short-term volatility. Thus, there is a possibility that either the two variables are negatively correlated with each other, or, at best, the relationship might be neutral if we believe that the governments of EMS countries have properly managed their exchange rates. However, if foreign exchange markets are not fully efficient, and if this inefficiency has been an important source of misalignment, the two variables could be positively correlated with each other. The reason is that: under the assumption of inefficiency in foreign exchange markets, without proper government intervention, nominal exchange rates can possibly be moved away from fundamentals due to inefficiency. Therefore, if EMS countries have efficiently controlled exchange rates during the sample period, they might have enjoyed both lower short-term volatility and less misalignment problems than countries using the free market system.

Although it is difficult to accept simple correlation as evidence of inefficiency in foreign exchange markets, the important finding is that this strong positive correlation cannot be easily explained by the traditional view of the floating system. I think that finding appropriate reasons for explaining this positive relationship between two measures is an important subject. However, with the given data set, I cannot examine this issue any further in this dissertation; it remains as a future research subject.

Overall, in connection with the evidence obtained from the previous section with this strong correlation, two similar interpretations might be plausible. First, although
short-term exchange uncertainty is relatively unimportant in the short- and medium-run, except for the agricultural sector, accumulated exchange rate uncertainty has affected the long run decision problem of economic agents resulting in a negative linkage between variables in the long run. Second, although short-term exchange rate uncertainty is not important in explaining trade growth rates in the long run, higher short-term volatility is an important signal of possible exchange rate misalignment. Although I can not identify which movements have dominantly affected international commodity trade in the long run, at least, we can confirm both issues are clearly connected with each other.

5.6. Discussion

High short-term volatility of exchange rates under the floating system has been another important issue connected with international trade. Although time-series evidence of the impact of short-term volatility is weak, some economists emphasize the importance of cross-country differences in terms of the effect of short-term exchange rate volatility on international trade. Using a cross-sectional approach, I found a long run negative relationship between short-term exchange uncertainty and trade growth in the case of total trade. These results are consistent with recent empirical evidence by Rose. Moreover, we can also observe different sectoral relationships between variables as indicated by Wolak and Kolstad. In the case of large-scale industries producing relatively differentiated products, we do not find any statistically significant linkage between variables. In contrast, in the case of industries producing relatively
homogeneous products, a long run negative linkage between variables is detected. Using panel data analysis, I found that the cross-country differences in short-term exchange rate uncertainty have been particularly harmful to agricultural trade in the medium-run, while time-series variations in exchange rate risk have not been very important in explaining time-series variations of trade growth rates in any cases. Finally, examining the cross-sectional relationship between short-term exchange rate uncertainty and long-term variability, I found a strong positive correlation between the two different measures.

In empirical studies in this area, the issues of short-term volatility and misalignment have been treated separately. For instance, Obstfeld (1995) concludes that short-term exchange rate volatility among developed countries has not had an important impact on international trade based on time-series empirical results. Simultaneously, he also indicates exchange misalignment may have had a more serious impact on international trade. However, the empirical results of this chapter suggest that countries that have faced higher short-term exchange volatility have also faced a larger misalignment problem during the post-Bretton Woods era. Overall, a clear finding in this chapter is that time-series variation of short-term exchange rate volatility is a relatively negligible factor to commodity trade, while cross-country differences of real exchange rate movements are important, especially, to agricultural trade.
CHAPTER 6

SUMMARY AND CONCLUSIONS

When the international monetary system changed from a fixed to a floating system, economists generally believed that this new market based system could substantially decrease the misalignment problems between countries. Although, this ideal belief strongly depended on a belief about foreign exchange markets, the realization of exchange rates under the floating system has not been matched by this ideal belief. Empirical evidence in this area suggests that foreign exchange markets have not been so efficient, so that nominal exchange rates have not represented macroeconomic fundamentals for long periods of time. Moreover, they have been extremely volatile in the short run. Although some economists believe that these problems have had a destructive effect on international commodity trade, there is still a considerable debate about their impact on international commodity trade. This paper has focused on two important movements of real exchange rates during the post-Bretton Wood era, and their linkages with agriculture trade growth among developed countries.
The first considered in the present paper is long-term real exchange rate variability, which is considered as a proxy variable for the magnitude of misalignment between countries. According to recent empirical evidence of PPP, real exchange rates among developed countries have reverted to their long run equilibrium levels, which confirms PPP as a long run equilibrium condition of nominal exchange rates between two countries. However, the empirical evidence also shows us that the deviation of real exchange rates from their long run equilibrium values has been substantial and persistent. While many economists have concentrated on persistency of real exchange rate movements, some economists such as Baldwin (1988), and Baldwin and Krugman (1989) emphasize that their magnitudes could be more importantly connected to international commodity trade. They argued that extreme under- (over-) valuations of a currency could possibly cause a real impact on international trade flows, while a moderate exchange rate shock could not. By a simple extension of their model, I showed this effect could vary by sector, depending on the extent of sunk costs of (re-) entering export markets. Relevant theory and empirical evidence of pricing to market show that traders strategically respond to given exchange rate movements, which also implies a possibility of different sectoral impacts of exchange rate movements. On the other hand, theory and empirical evidence of 'political economics' suggests the possible negative impact of long-term real exchange rate variability on international trade due to increasing protectionism. Using cross-section and panel data analyses with a sample of ten developed countries over the period 1974-1995, I examined this issue empirically, and several important findings were obtained.
First, at a total trade level, there was weak evidence that long-term real exchange rate variability can be linked with the trade growth rate. For instance, cross-sectional analyses weakly supports a negative linkage, while panel data analysis does not support the link between variables. In their earlier study, De Grauwe and de Bellefroid (1986) found a significant negative relationship between variables using a sample of 1973-1984 with the same country pairs, but employed a different measure of the magnitude of misalignment. With eleven more years in the sample, I find much weaker evidence than theirs. Second, for the large-scale industries (i.e., machinery and chemicals), I do not find any statistically significant linkage between variables. Both cross-section and panel data analyses consistently reject the linkage between variables. In connection with the hysteresis model, this neutrality might imply that the market based floating system has not generated exchange rate shocks, which are large enough to exceed the boundaries of the inaction range of these industries. Third, however, I found that the realization of exchange rate misalignment has been large enough to cause a real negative impact on commodity trade for sectors producing relatively homogeneous products. Compared to other sectors, the growth of agricultural trade has been adversely affected by long-term variability in real exchange rates. Both cross-sectional and panel data analyses consistently support a negative linkage between variables in the case of the manufacturing and agriculture sectors. Fourth, I found some empirical evidence that supports the hysteresis effect of exchange rates suggested by Baldwin and Krugman. Although, in some large-scale industries, the asymmetric realizations of exchange rates have not caused the hysteresis effect, in the case of the manufacturing
and agricultural sectors, we can observe the hysteresis effect of exchange rates. In other words, the empirical results of the present study support the hypothesis that a huge unfavorable exchange rate shock has more negatively affected export growth rate in those industries than several moderate favorable shocks. These results show us why huge real appreciation of the US dollar in the mid-1980s had impacts that were more destructive on the US agricultural sector than on large-scale manufacturing sectors. This conclusion is consistent with that of Tweeten (1989: Chapter 6). Fifth, the empirical results suggest that the reaction of growth rates of agricultural trade in response to real exchange rate movements has been almost four times more than that of total trade in the long run, 20–60 percent in the medium run. In their earlier studies, Gardner (1981), and Chambers and Just (1981) found that a change in the US dollar movement substantially affected real farm prices. For instance, Gardner found a 10 percent devaluation of the US dollar in nominal terms generates a 4 percent increase in real farm prices. Chambers and Just found that a 10 percent devaluation of the US dollar was associated with an 8 to 20 percent increase in prices of major farm products. If we believe that variations of US agricultural exports have caused variations in

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1 Under the flexible price monetary model which assumes PPP holds even in the short-run, these earlier empirical results triggered a debate about the effect of inflation on farm prices. For instance, under the assumption that PPP holds continuously, we can interpret Gardner’s finding as follows. Under the assumption of a zero inflation rate in a foreign country, a 10 percent devaluation of the dollar should be due to a 10 percent increase in US inflation rates, which could not affect international trade by assumption of PPP. Therefore, Gardner’s finding implies a 10 percent increase of inflation rates is associated with a 10.4 percent increase in nominal farm prices which results in a 4 percent increase in real farm prices. Therefore, under the assumption of continuous PPP, the empirical result implies that agricultural prices react more than the inflation rate.
domestic agricultural prices, our results can support these earlier empirical results although we can not directly compare our results with theirs.

The second movement of real exchange rates considered in the present study is short-term exchange volatility. Although time-series evidence of the effect of short-term volatility on international commodity trade is weak as a whole, or mixed at best (Obstfeld 1995), some economists have emphasized the importance of cross-country differences in short-term exchange rate volatility on international trade. For instance, using a gravity type model with a large cross-sectional data set, Rose (2000) shows that both currency union and exchange rate volatility are important variables affecting trade growth. Using cross-section and panel data analyses, some findings are obtained in connection with this second topic.

First, using a cross-sectional approach, I found a negative relationship between a short-term exchange volatility measure, which was considered as a proxy variable of exchange rate uncertainty, and trade growth in the case of the total, manufacturing, and agricultural sectors in the long run. However, for large-scale industry, the effect seems to be neutral. These results imply that different degrees of product differentiation of industry sectors is an important factor in determining the relationship between variables. As Wolak and Kolstad indicate, it is possible that exchange rate uncertainty could more adversely affect the trade of industries producing relatively homogenous goods.

Second, I found that cross-sectional variations of short-term exchange rate uncertainty have not affected trade growth in most of the cases in the medium-run. The only

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2 Because we do not know relationship the between US export and US domestic agricultural prices, we can not directly compare both results.
exception is agricultural trade. A negative linkage between variables is found in this case. Third, however, I do not find any empirical evidence that time-series variations of short-term exchange rate uncertainty have negatively affected international commodity trade in any cases. With these results, we find a reason to believe that short-term exchange rate volatility is still an important issue for agricultural trade, although the time-series evidence is weak. Finally, examining the cross-sectional relationship between short-term exchange rate uncertainty and long-term variability measures, I found a strong positive correlation between variables. This result implies that countries that have faced higher annual volatility have also faced larger misalignment problems during the sample period. Although it is difficult to identify which movements dominantly affect international commodity trade in the long run, at least, we can confirm both issues are clearly connected with each other.

Overall, the results presented in this paper make a potential contribution to our understanding of the connection between exchange rate movements and international agricultural trade flows. Traditionally, agricultural economists have believed that behavior of exchange rate movements during the post-Bretton Woods era has been due to disturbances of underlying macroeconomic fundamentals between countries. It might be true that underlying movement of macroeconomic variables might be important factors of explaining nominal exchange rate movements. However, in general, the fundamental difficulty of explaining exchange rate movements under the floating system is not because of their strong linkages with macroeconomic fundamentals but because of their de-linkage from macroeconomic fundamentals for
long time periods. On the other hand, the literature has focused on the impact of increased short-run exchange rate volatility on agricultural trade based on a time-series approach. However, the results of the present paper suggest that cross-country differences in short-term exchange rate volatility have been more important for international agricultural trade. Therefore, it is desirable that agricultural economists should concentrate more on cross-country differences of exchange rate movements in their future research.

As many economists have indicated a sound macroeconomic policy of a country might be important for stabilizing exchange rates (\textit{i.e.}, Tweeten, 1989: Kliesen and Poole, 2000). However, independently pursued macroeconomic policies of a country alone might not be enough to prevent the possible instability problem of agricultural trade in the future, if some degree of inefficiency in the foreign exchange markets have played an important role in explaining abnormal behavior of exchange rates under the floating system. Internationally coordinated exchange rate management policy may have beneficial effects on trade flows for the agricultural sector.

\footnote{Recent empirical evidence shows that US monetary policy has an important role in explaining variations in US dollar based real exchange rates. For instance, Eichenbaum and Evans (1995) found around 17 percent variation in US real exchange rates can be explained by US monetary policy variation during the flexible exchange rate system. Recently, Rogers (1999) also found that US monetary policy has been responsible for a minimum 20 percent variation of real exchange rates between the dollar/pound real exchange rate during the period of 1889-1992. Therefore, it could be true that unstable macroeconomic policy of a country is one of the important sources of the misalignment problem during the floating system.}

\footnote{If countries pursued independent macroeconomic policies, the fixed exchange rate system might not be sustainable. However, as Mundell (2000) argued in his Nobel prize lecture, if we believe that radical changes in macroeconomic policies are not helpful to an economy so that countries pursued stable macroeconomic policies, the flexible exchange rate system might not be the optimal form of international monetary system. If one of the important sources of exchange rate fluctuation under the floating system is some degree of inefficiency in foreign exchange markets, a stable but independent macroeconomic policy in a country alone cannot prevent unnecessary instability in the international price system.}
Finally, it is important to discuss some additional important points in order to prevent a chance of inappropriate interpretation of the empirical results of the present paper. First, it is important to note here that the empirical results of this study do not support any conclusion that the floating exchange rate system is more harmful to the world economy than is the fixed exchange rate system. Simply, international trade alone cannot be a proper indicator of success of an international monetary system. Moreover, the fixed exchange rate system itself produced misalignment problems, which could cause much more serious problems than those under the floating exchange rate system, especially in the long run. Rather than this simple interpretation, I tried to reveal an important issue, which is mostly ignored in macroeconomic level studies: the different sectoral effects of exchange rates. For instance, under the floating system, exchange variability might not be large enough to affect total trade in the long run. However, it does not mean its neutrality for all industry sectors in an economy, because it could be large enough to cause real instability for some sectors such as agriculture. This asymmetric effect of exchange rate movements could affect the long run decision problems of investors resulting in a resource reallocation problem in an economy. The agricultural sector might experience the most unfavorable impact in these circumstances.

Second, the negative linkage between variables in the agricultural sector does not mean that there has been a decrease in the welfare of farmers who have experienced more variability of real exchange rates during the sample period. If cyclical swings of real exchange rates caused strong government intervention (protectionism) in the
agricultural sector, the welfare loss of consumers could be large. On the other hand, farmers who do not have comparative advantage in the world market could have gained under the floating system. Under the General Agreement on Tariffs and Trade (GATT) agreement, many agricultural economists expect this welfare loss can be resolved substantially. However, some economists such as McKinnon (1995) have suggested a pessimistic view about the success of GATT. Simply, unless exchange rate stability is first achieved, the incentive for protectionism due to unfavorable exchange rate movements is not resolved, so that we can expect that people will develop new types of protectionism in the future.

Third, the neutrality results in large-scale industries does not mean that there is no effect of misalignment in these sectors. Some economists seem to believe that price adjustment behavior of large-scale industries is evidence of imperfect competition. Consequently, adjustment of the export price has been interpreted to have the same meaning as adjustment of their markup. However, in reality, even in the case of large-scale industries, we can easily observe that firms have suffered from unfavorable movement of exchange rates. To overcome this unfavorable situation, they could cut down their variable costs, labor (or wage), which might cause substantial fluctuation in the labor market. In their sequential papers, Borjas and Ramey (1994, 1995) show that the US trade deficit in durable goods has been positively correlated with wage inequality between skilled and unskilled workers. Moreover, they found that trade alone could explain about half of the decline in employment in the concentrated industries during the period from 1976 to 1990. Considering the strong correlation
between US trade deficits and the US dollar movements, we cannot rule out a possibility that long-term exchange rate variations have been associated with variations in the labor market, which results in an increasing income inequality in an economy.

For the whole economy, instability must be one important problem of exchange rate movements under the floating system. It is possible that exchange rates movements could cause a cyclical boom and depression of industry sectors, which causes resources to move back and forth from one sector to another, and distort long-run investment decisions. Consequently, there could be huge deadweight costs in the adjustment process. Although I can not investigate the above important issues in this dissertation, these issues are clearly important subjects of future research.

\footnote{Recently, Romer and Romer (1999) used data for a large sample of countries from 1970s and 1980s, and found an important negative relationship between the income of the poor and broadly defined macroeconomic instability in the long run.}
APPENDIX

PANEL ECONOMETRICS

In this dissertation, different panel econometric methods under different assumptions of the underlying data generating process (DGP) are employed. In fact, understanding properties of these estimators is important for interpreting the final estimation results. In this appendix, therefore, I will briefly review the panel econometrics used in this dissertation\(^1\). I first review properties of estimators under the assumption of different constant terms but the same slope coefficients across cross-sectional units based on unified framework suggested by Maddala (1971). Here, it will be explained why the 'within' estimator (or cross-sectional fixed effect model) ignores cross-sectional variation in the data, so that should be interpreted in the time-series sense. Second, a two-step estimation procedure suggested by Hausman and Taylor (1981) to handle time-invariant variables in the regression model will be explained. A discussion about the possible correlation between an unobservable cross-sectional latent effect and time-invariant variables will be also presented. Finally, an estimation

\(^1\) If readers want to know more of the theoretical discussion of panel econometric analysis, Hsiao (1986), and Judge et al. (1985) will be helpful.
procedure which is derived from the assumption of all the coefficients are different across cross-sectional will be discussed based on the Swamy (1970) and Hsiao (1986) estimation procedure. Moreover, an extension for estimating time-invariant variables under their model specification will be introduced.

A.1. General

The most basic panel data model specification might be the following:

\[(A.1) \quad Y_{it} = \alpha + X_{it} \beta + \varepsilon_{it},\]

where \(Y_{it}\) is an \(NT \times 1\) vector of dependent variable, \(X_{it}\) is an \(NT \times k-1\) matrix of independent variables, and \(\varepsilon_{it}\) is an \(NT \times 1\) vector of error terms assumed to have mean zero and variance \(\sigma^2\) and assumed to be uncorrelated with the independent variables. \(N\) is numbers of cross section units, \(T\) is numbers of time series units, and \(k\) is numbers of independent variables including constant term. It should be noted here that there is no cross-sectional subscript \(i\) on \(\alpha\) and \(\beta\) in this model. If the above assumptions are true, the obvious choice is the ordinary least squares (OLS) estimator.

A.2. Alternative Assumption I

If we combine time-series and cross-sectional data, it is natural to assume that there is an unobservable cross-sectional specific latent effect such as distance between countries. In this case, we can express the model as:

\[(A.2) \quad Y_{it} = \alpha_i + X_{it} \beta + \varepsilon_{it}.\]
It is important to note here that now there is a cross-sectional subscript i on \( \alpha \), while there is no cross-sectional subscript i on \( \beta \) in this model.

Under the assumption of \( \alpha_i \) being fixed, two estimation methods are popularly used. First, we can use the OLS estimator with cross-section dummy variables. This is called a least squares with dummy variable (LSDV) estimator in the relevant literature. Second, if there are many cross-section units, using cross-sectional dummy variables are burdensome. In this case, we can simply eliminate the individual fixed effects by transforming the data into deviation from individual means and then apply OLS to the transformed data. This is so called the 'within' estimator in the relevant literature. However, the estimation results for the slope coefficients must be the same as those of the LSDV estimator.

If we believe \( \alpha_i \) is a random variable distributed with mean \( \mu \) and variance \( \sigma^2_\alpha \), we call it a 'random effect' model specification. Under this assumption, equation (A.2) can be expressed as:

\[
(A.3) \quad Y_{ui} = \mu + X_{ui} \beta + \eta_i \quad \text{where} \quad \eta_i = \alpha_i + \varepsilon_{ui}.
\]

There have been different generalized least square estimators (GLS) in the literature for estimating this model. For instance, Wallace and Hussain (1969), Maddala (1971), Amemiya (1971), and Fuller and Battese (1973) all suggest slightly different GLS estimators under the random effect assumption. The choice among OLS, within, and GLS estimators is important because under the different assumptions about underlying data generating process (DGP), the properties and interpretations of the estimators are different from each other. To explain this point, I first review the relationship among
estimators using the unified framework introduced by Maddala (1971), and then discuss the properties of estimators when some of independent variables are correlated with the individual latent effect \( \alpha_i \).

Maddala summarized the relationship among OLS, within, and generalized least square (GLS) estimators under a unified framework. According to Maddala, we can express (A.3) in a more compact form:

\[ \begin{align*}
Y &= X\beta + \eta \\
\text{where } \eta_{it} &= \alpha_i + \epsilon_{it}.
\end{align*} \]

\( Y \) is an \( NT \times 1 \) vector of dependent variable, \( X \) is an \( NT \times k \) matrix of independent variables, and \( \eta \) is an \( NT \times 1 \) vector of error term. In this case, we can define the covariance matrix of error term \( \eta \) as:

\[ \begin{align*}
E(\eta \eta') &= \Omega = \sigma^2 \begin{bmatrix}
A & 0 & \cdots & 0 \\
0 & A & \cdots & 0 \\
\cdots & \cdots & \cdots & \cdots \\
0 & 0 & \cdots & A
\end{bmatrix},
\end{align*} \]

where \( A \) is the \( T \times T \) matrix:

\[ \begin{align*}
A &= \begin{bmatrix}
1 & \rho & \cdots & \rho \\
\rho & 1 & \cdots & \rho \\
\cdots & \cdots & \cdots & \cdots \\
\rho & \rho & \cdots & 1
\end{bmatrix},
\end{align*} \]

and \( \sigma^2 = \sigma^2_a + \sigma^2_e \), \( \rho = \sigma^2_a / \sigma^2 \). He further defines the following unified expression:

\[ T_{xx} = \sum_{i=1}^{N} X_i'X_i, \]

\[ B_{xx} = \frac{1}{T} \sum_{i=1}^{N} (X_i'ee'X_i), \]
where $e$ is a $T \times 1$ vector with all elements unity. And, similarly we can define $T_{xy}$, $B_{xy}$, and $W_{xy}$. Now, we can define usual GLS estimators of this line as:

\[(A.8) \quad \hat{\beta}_{GLS} = [W_{xx} + \Theta B_{xx}]^{-1}[W_{xy} + \Theta B_{xy}],\]

where $\Theta = (1 - \rho)/(1 - \rho + \rho T) = \sigma_e^2/[(\sigma_e^2 + T\sigma_x^2)^2]$. With this unified framework, we can define OLS, between, and within estimators as follows:

\[(A.9) \quad \hat{\beta}_{OLS} = [T_{xx}]^{-1}T_{xy} = [W_{xx} + B_{xx}]^{-1}[W_{xy} + B_{xy}],\]

where $\hat{\beta}_{OLS}$ is the OLS estimator, $\hat{\beta}_{B}$ is the 'between' estimator, and $\hat{\beta}_{W}$ is the 'within' estimator. An important intuition with this unified framework is that in the 'within' estimator, the cross-section variation of variables are completely ignored ($\theta = 0$). In the OLS estimator, the cross-section and time-series variation of the sample is just added up ($\theta = 1$), finally, in the 'between' estimator, the time-series variation of variables are completely ignored. Therefore, Maddala argued that GLS estimators are a compromise solution to find a weight which utilizes time-series and cross-sectional variation of variables. In summary, if independent variables are not correlated with the error term, (i.e., $E(\alpha_i \mid X) = 0$), GLS estimator is best liner unbiased estimator (BLUE).

2 Maddala and Mount (1973) further showed that different GLS estimators suggested by different authors are just difference of suggestion of consistent estimator of $\theta$.  

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140
The 'within' estimator is still unbiased and consistent but less efficient than the GLS estimator because it ignores cross-sectional variation of the data.

However, according to Mundlack (1978), if some of the independent variables are correlated with the unobservable latent effect $\alpha$, (i.e., $E(\alpha | X) \neq 0$), the GLS estimators are biased. Only the 'within' estimator is an unbiased and consistent estimator in this case. Therefore, choice between GLS and 'within' estimator is simply a trade-off between efficiency and biasedness if we do not know whether some of the independent variables are correlated with the unobservable individual effect $\alpha_i$. In this paper, I used the 'within' estimator because the unbiasedness property of estimator is more important than efficient gain. However, Maddala's interpretation is important for interpreting the estimation results of the 'within' estimator. Because it depends mainly on the time-series variation of the data, the interpretation should be in the time-series sense.³

A.2.1. With Time-Invariant Variable (Hausman and Taylor Estimator)

Now, consider a model including time-invariant variables $Z_i$ in equation (A.2) that are expected to be correlated with cross-sectional variation of the dependent variable. There have been some econometric considerations about the case where the model contains time-invariant variables (i.e., Hausman and Taylor, 1981: Amemiya and MaCurdy, 1985: Breusch et al., 1989). Among them, I will concentrate on the two-step procedure suggested by Hausman and Taylor. Before I further explain their estimation
procedure, it is important to discuss the relationship between the time-invariant variables and the unobservable individual latent effect \( \alpha_i \). Hausman and Taylor considered a case when there is a correlation between time-invariant variables \( Z_i \) and \( \alpha_i \) (i.e., \( E(\eta_i | Z_i) \neq 0 \)). Under the assumption of this correlation, empirical researchers need to use an additional instrumental-variable (IV) method to obtain the coefficients of time-invariant variables. When we do not have proper instrumental variables, therefore, this is a serious limitation for applying the method in an empirical study. Therefore, I impose an assumption on the relationship between time-invariant variables and the unobservable latent effect \emph{a priori}. To explain this point, first, I re-write the econometric specification (A.2),

(A.2) \[ Y_{it} = \alpha_i + X_{it}\beta + \varepsilon_{it}. \]

As before, \( \alpha_i \) is an unobservable individual latent effect, which is expected to capture cross sectional variation of the dependent variable. When we include time invariant variables \( Z_i \) into the regression equation, it might be logically reasonable that \( Z_i \) should be treated as a subset of \( \alpha_i \). With this view, we can further assume the following relationship holds:

(A.10) \[ \alpha_i = \mu + Z_i\gamma + \eta_i, \]

where \( \eta_i \) is a remaining latent effect \( \alpha_i \), which is not captured by time invariant variable \( Z_i \). We further assume \( \eta_i \) is a random variable, equation (A.2) becomes:

\[ Y_{it} = \mu + Z_i\gamma + \eta_i + X_{it}\beta + \varepsilon_{it}. \]

\footnote{In the case of the time fixed effect model used in the chapter 5, a reverse explanation can be applied, so that the estimated coefficients are mainly based on the cross-sectional variation of the data.}
This is a similar specification of the usual random effect specification (A.3). However, under this point of view, we can eliminate a possibility that $E(\eta_i \mid Z_i) \neq 0$ due to the orthogonality condition of equation (A.10): simply, if equation (A.10) is true, then $E(\eta_i \mid Z_i) = 0$. Then, we can treat the time-invariant variable $Z_i$ as strict exogenous variables so that we can directly estimate $\gamma$ with the usual OLS estimator.

Hausman and Taylor (1981) suggest a convenient two step procedure to estimate model with time-invariant variables within panel data analysis. Their idea is simple: at the first stage, use the ‘within’ estimator to obtain estimates of the independent variable $X$. For the second stage estimation, construct a proxy variable of the individual latent effect $\hat{\alpha}_i$. At the second stage estimation, using a cross-sectional approach, we can obtain coefficients on the time-invariant variables $Z_i$. To explain their estimation procedure formally, it is convenient to define two conventional orthogonal projection operators:

\[(A.12) \quad P_\nu = \left[I_N \otimes \frac{1}{T}I_TI_T^\prime \right], \quad Q_\nu = I_{NT} - P_\nu,\]

which are both idempotent matrices. $\tau_i$ is a $T \times 1$ vector with all elements unity, $I_N$ is an $N \times N$ identity matrix, $I_{NT}$ is an $NT \times NT$ identity matrix, and $\otimes$ is a kronecker product of two matrices. With data grouped by individuals, $P_\nu$ transforms a vector of observations into group means: i.e., $P_\nu Y_i = (1/T) \sum Y_{it} = \bar{Y}_i$. Similarly, $Q_\nu$ produces a vector of deviations from group means: i.e., $Q_\nu Y_i = \bar{Y}_i - \bar{Y}_i$. Moreover, $Q_\nu$ is
orthogonal by construction to any time-invariant vector of observations:

\[ Q'_v Z_i = \bar{Z}_i - \frac{1}{T} \sum Z_i = 0 \]. The suggested two steps are as follows.

At the first stage of estimation, transform the equation (A.11) by \( Q'_v \) under the assumption of a fixed effect \( \eta_i \), obtaining:

\[ Q'_v Y_{it} = Q'_v \mu + Q'_v X_{it} \beta + Q'_v Z_i \gamma + Q'_v \eta_i + Q'_v \varepsilon_{it}. \]  

This procedure eliminates all the time-invariant variables, for instance, \( \mu, \eta_i \) and \( Z_i \) in our case, and we can rewrite it as:

\[ Q'_v Y_{it} = X_{it}' \beta + \tilde{\eta}_{it}. \]  

Applying an OLS estimator to equation (A.14), we can obtain unbiased and consistent estimates \( \hat{\beta}_{iw} \). However, all time-invariant variables are eliminated by the transformation so that we can not estimate \( \gamma \), which are the most important coefficients in the present study. To obtain estimated coefficients of \( \gamma \), define the following relationship:

\[ \hat{d}_i = \bar{Y}_i - \bar{X}_i \hat{\beta}_{iw} = [P_{iw} - \bar{X}_i (X_{it}' Q'_v X_{it})^{-1} X_{it}' Q'_v] Y_{it}. \]  

If we further expand this expression, we can easily have,

\[ \hat{d}_i = \bar{Y}_i - \bar{X}_i \hat{\beta}_{iw} = \mu + Z_i \gamma + \eta_i + [P_{iw} - \bar{X}_i (X_{it}' Q'_v X_{it})^{-1} X_{it}' Q'_v] \varepsilon_{it}. \]  

By treating the last two terms as an unobservable mean zero disturbance \( \zeta_i \), at the second stage estimation, the following auxiliary regression will be estimated,

\[ \hat{d}_i = \mu + Z_i \gamma + \zeta_i. \]  

Hausman and Taylor further discuss IV approach due to a possibility of correlation
between the time-invariant variable $Z$, and the unobservable latent effect $\alpha_i$. However, as discussed earlier, even when there is a remaining individual effect in the error term, that cannot be correlated with $Z$, if our model specification is correct. Therefore, we can directly estimate equation (A.17) without using the IV estimator. Hausman and Taylor show that this two step procedure gives us consistent estimates of $\gamma$ if $Z_i$ are exogenous, and we have large cross-section units. It is important to note here that the estimated coefficients on variables from first stage of the regression are obtained by the 'within' estimator so that it might be better to interpret them in the time-series sense. On the other hand, the estimated coefficients from the second stage of regression are obtained by a cross-sectional regression so that it might be better to interpret them in the cross-sectional sense.

### A.3. Alternative Assumption II: Random Coefficient Model (RCM)

Under the assumption of heterogeneity of all coefficients across cross-sectional units, we define a general RCM specification as follows:

\[
Y_{it} = \alpha_i + X_{it}\beta_i + \varepsilon_{it},
\]

where all the coefficients are treated as random variables that have mean $\mu$ and $\bar{\beta}$, and finite variances. The estimation methods suggested by Swamy (1970), Pesaran and

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4 Usually, researchers implement a poolability test based on a Chow type F-test to test which assumption is correct. However, Baltagi and Griffin (1983, 1997) argue that the statistical power of the Chow test is too strong so that the test usually rejects the null of poolability hypothesis. In addition, they argue that efficiency gains from pooling appear to more than offset the biases due to cross-section heterogeneity. On the other hand, Pesaran and Smith (1995) show that, estimation results under the random coefficient model (RCM) will converge to the results from within estimator if the lagged dependent variable is not included as a right-hand side variable.
Smith (1995), and Maddala et al. (1997) are all based on this random coefficient assumption. Including the time-invariant variable $Z$, into (A.18), and further assuming (A.10) holds, equation (A.18) becomes:

$$(A.18') \quad Y_{it} = \mu + Z_i \gamma + X_{it} \beta_i + \eta_i + \varepsilon_{it},$$

However, the difficulty comes from the fact that all the estimation procedures in the RCM specification are based on the separate regression results of each cross-section unit. If the main objective of a study is estimating the effect of a time-invariant variable, the RCM estimators can not be applicable due to a perfect collinearity problem. According to my knowledge, there is still no particular estimation procedure for estimating a time-invariant variable under the RCM specification. In this section, therefore, I introduce an estimation procedure to estimate time-invariant variables under the RCM specification. The basic idea of this procedure is similar to that of Hausman and Taylor (1981).

At the first stage of estimation, transform model (A.18') by $Q_v$ under the assumption of a fixed effect $\eta_i$. We obtain the following equation,

$$(A.19) \quad Q_v Y_{it} = Q_v \mu + Q_v X_{it} \beta_i + Q_v Z_{it} \gamma + Q_v \eta_i + Q_v \varepsilon_{it},$$

which implies,

$$(A.20) \quad \bar{Y}_{it} \equiv \bar{X}_{it} \beta_i + \bar{\varepsilon}_{it}.$$

Now, further assume underlying distribution of $\beta_i$,

$$(A.21) \quad \beta_i = \bar{\beta} + \eta_i ,$$

where $\eta_i \sim IID(0, \Sigma)$. With this model specification, we can rewrite equation (A.20) as,
where \( \omega_i \sim \text{IN}(0, \Omega_i) \), with \( \Omega_i = (\tilde{X}_i \Sigma \tilde{X}_i^\prime + \sigma_i^2 I) \). This is, in fact, a typical model specification of RCM. Therefore, at the first stage estimation, we use a RCM estimation procedure suggested by Swamy (1970) and Hsiao (1986) to estimate coefficient \( \hat{\beta} \) with the transformed data. If the slope coefficients are different in each cross-section, the estimated \( \hat{\beta} \) is unbiased estimator of the average effect \( \bar{\beta} \). The following procedure was used for the first stage of estimation. Under the model specification (A.22), the GLS estimator introduced by Swamy is:

\[
(A.23) \quad \hat{\beta} = (\tilde{X}\bar{\Omega}^{-1}\tilde{X})^{-1}\tilde{X}^\prime\bar{\Omega}\tilde{Y} = \left( \sum_{j=1}^{N} \tilde{X}_j^\prime \Omega_j^{-1} \tilde{X}_j \right)^{-1} \sum_{j=1}^{N} \tilde{X}_j^\prime \Omega_j^{-1} \tilde{Y}_j = \sum_{i=1}^{N} W_i \hat{b}_i,
\]

where,

\[
(A.24) \quad W_i = \left\{ \sum_{j=1}^{N} \left[ \Sigma + \sigma_u (\tilde{X}_j^\prime \tilde{X}_j)^{-1} \right]^{-1} \right\}^{-1} \left[ \Sigma + \sigma_u (\tilde{X}_j^\prime \tilde{X}_j)^{-1} \right],
\]

and \( \hat{b}_i = (\tilde{X}_i \tilde{X}_i^{-1} \tilde{X}_i^\prime \tilde{Y}_i \) is the least squares estimates of each group with the transformed data. Therefore, the basic idea of the RCM estimation procedure is to estimate average effect, \( \hat{\beta} \), using a weighted average of OLS estimates of individual time-series regression \( b_i \). Recently, Pesaran and Smith also suggested that an unweighted method is also a consistent estimator of \( \bar{\beta} \). In this case, the estimated \( \hat{\beta} \) is:
In this study, I used the weighted method suggested by Swamy which is more efficient than the unweighted method.

Unknown components in equation (A.24) are $\Sigma$ and $\sigma_u$, which need to be replaced by consistent estimators to be GLS estimator feasible. The suggested unbiased estimators by Swamy are:

\[(A.26) \quad \hat{\sigma}_u = \frac{\tilde{e}' \tilde{e}}{T - k},\]

which is an estimated variance based on each individual regression, and,

\[(A.27) \quad \hat{\Sigma} = \frac{S_b}{N - 1} - \frac{1}{N} \sum_{i=1}^{N} \hat{\sigma}_u (\bar{X}_i' \bar{X}_i)^{-1},\]

where, $S_b = \sum_{i=1}^{N} b_i b_i' - \frac{1}{N} \sum_{i=1}^{N} b_i' - \frac{1}{N} \sum_{i=1}^{N} b_i$. One difficulty of Swamy’s estimator $\hat{\Sigma}$ is that it may not be nonnegative definite. In this case, Hsaio (1986) suggested using $\hat{\Sigma} = \frac{S_b}{N - 1}$ instead. These procedures are called the Swamy-Hsaio estimator in the literature.

However, as we previously mentioned, this first stage estimation does not give us any estimates of the time-invariant variable $Z$, which is the most important variable for the present research. Therefore, for the second stage estimation, define the following relationship:

\[(A.28) \quad \hat{d}_i = \bar{y}_i - \bar{X}_i \hat{\beta} = [P_v - P_v X_u (X_u' Q_v \hat{\Omega}^{-1} Q_v X_u)^{-1} X_u' Q_v \hat{\Omega}^{-1} Q_v ] Y_u.\]
If we further expand the equation (A.28), we can easily obtain equation (A.29):

(A.29) \[ \hat{d}_i = \bar{Y}_i - \bar{X}_i \hat{\beta} = \mu + Z_i \gamma + \eta_i + [P_{v} - \bar{X}_i (\bar{X}_u \hat{\Omega}^{-1} \bar{X}_u)^{-1} \bar{X}_u \hat{\Omega}^{-1} Q_v \bar{X}_u] \varepsilon_{u} \] .

The equation (A.29) is a matched equation (A.16) in the context of Hausman and Taylor. Therefore, without further consideration of the properties of the estimator followed by Hausman and Taylor, we treat the last two terms as an unobservable mean zero disturbance \( \xi_i \). We can obtain the following regression equation:

(A.30) \[ \hat{d}_i = \mu + Z_i \gamma + \xi_i , \]

where \( \eta_i \) is an unobservable mean zero disturbance. Therefore, at the second stage estimation, we use an OLS estimator to obtain consistent estimates for coefficients \( \gamma \) and \( \mu \).
LIST OF REFERENCES


